DOCUMENT RESUME

ED 241 260 SE 041 797

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TITLE	Do You Know Our Marine Fish? A Marine Education Infusion Unit.
INSTITUTION	Maine Univ., Orono. Coll. of Education.
SPONS AGENCY	National Oceanic and Atmospheric Administration (DOC), Rockville, Md. National Sea Grant Program.; National Science Foundation, Washington, D.C.
PUB DATE	82
GRANT	SER-8160322
NOTE	73p.; Prepared by Northern New England Marine Education Project. Also supported by the Maine Marine Advisory Program.
PUB TYPE	Guides - Classroom Use - Materials (For Learner) (051) -- Guides - Classroom Use - Guides (For Teachers) (052)
EDRS PRICE	MF01/PC03 Plus Postage.
DESCRIPTORS	*Ecology; Educational Games; Environmental Education; Experiential Learning; *Ichthyology; Instructional Materials; *Interdisciplinary Approach; Intermediate Grades; Junior High Schools; Learning Activities; *Marine Biology; *Marine Education; Middle Schools; Oceanography; Outdoor Education; Puzzles; Science Education; Units of Study; Word Lists
IDENTIFIERS	Dissection; Fishes; Fishing; Fishing Industry; Fish Products; Gulf of Maine; New England; PF Project

ABSTRACT

Designed to provide teaching materials for middle school and junior high school teachers in northern New England, this marine education unit presents teacher-tested ideas and activities for use in the classroom and in field trips to the ocean. Each unit includes ideas and activities drawn from a variety of content areas so teachers of many different subjects can make use of them. Although specific objectives are given for each activity, the unit has two general objectives: (1) to help students develop improved knowledge about marine fish, and (2) to develop increased awareness of the beauty and complex interrelatedness of marine fish. Students learn about these complex interrelationships by studying fish shapes, classes of fish, sharks, bony fish, fish feeding, commercial fishing, recreational fishing, deep sea fishing, fish aging, and growth. The bulk of the unit consists of student materials and activities including arts and crafts, creative writing, fish in literature, a lesson on cleaning and preparing fish, visual aids, games, fish observation, dissection instructions and diagrams, identification keys, tables, and checklists. Teacher resources include recipes, organizational resources, a directory of fish packers, and an annotated bibliography of books and films. (LH)

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Do You Know Our Marine Fish?

A Marine Education Infusion Unit

Units Revision Team

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Acknowledgement of Support

The original editions of these units were supported by the College of Education and the Maine-New Hampshire Sea Grant College with funding from the Office of Sea Grant, NOAA, U.S. Department of Commerce.

This edition is based on work supported by the National Science Foundation under Grant No. SER 8160322 and the Maine Marine Advisory Program.

Any opinion, findings, and conclusions or recommendations expressed in this publication are those of the authors and do not necessarily reflect the view of the National Science Foundation.

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Revised Marine Education Infusion Units for Middle School-Junior High School

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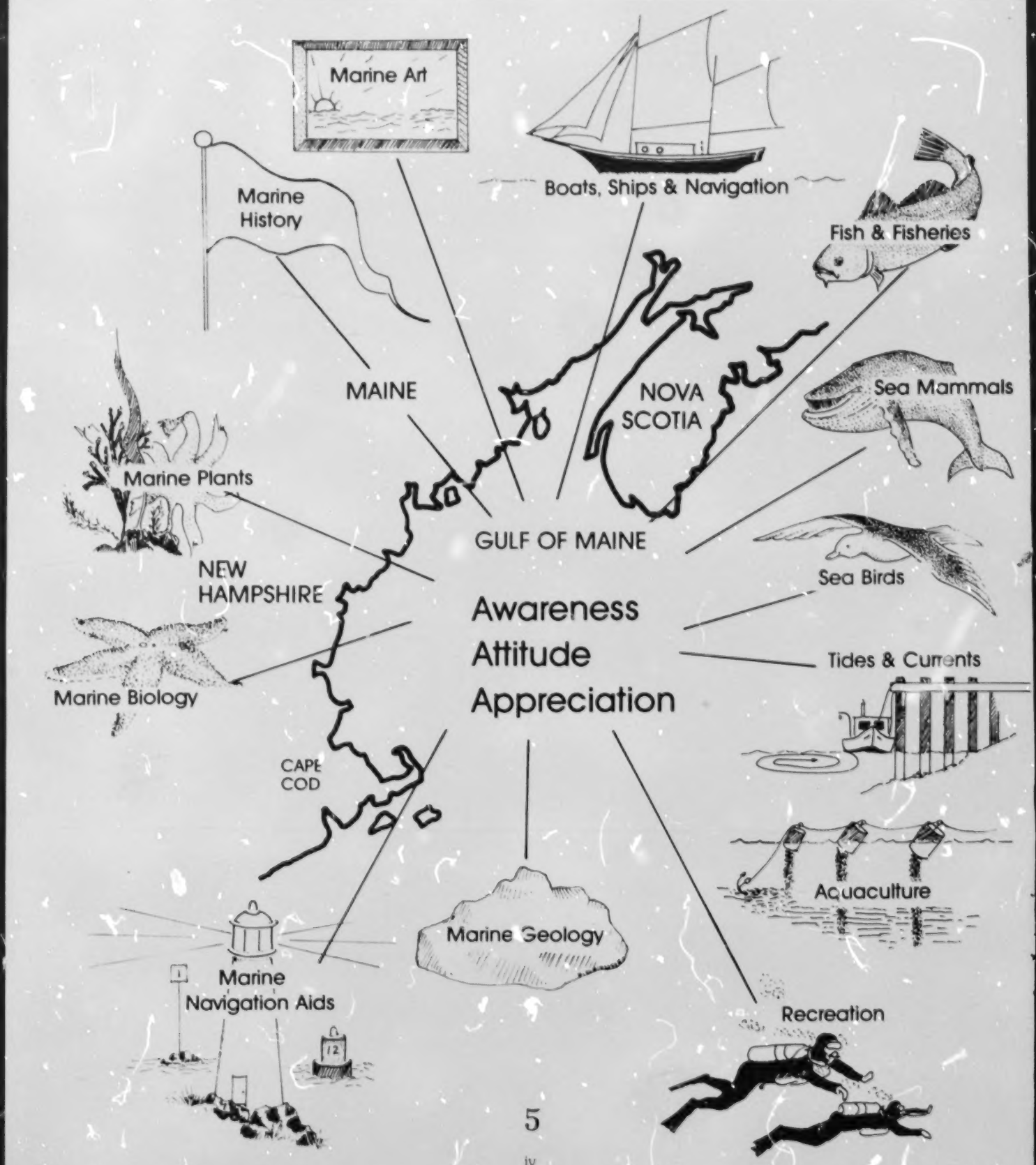
Blue Mussel
Lighthouses
Wetlands
Seaweeds
Aquaculture
Navigation

More than one hundred teachers and members of past NSF sponsored summer institutes have trial tested and critiqued these units.

Marine Education

Ocean & Coast Conceptual Scheme



Foreword

Marine education is a relatively new term embracing a multi-disciplinary approach to learning about the marine environment: how it relates to people and how people change and relate to it. These units are intended to serve as points of departure for teachers and students who desire to increase their awareness of the watery world of this blue planet. Each unit includes ideas and activities drawn from a variety of content areas so that teachers of many different subjects at the junior high and middle school levels can make use of them. These units may be used in their entirety or used as idea or activity sources to infuse into the usual curriculum.

Our objective is to help teachers make learning more water-related. We did not plan a structural sequence of topics for grades five through nine, but rather offer these teachers guides and student pages for your consideration.

The general focus within these units is the Gulf of Maine. As the Gulf extends from Cape Cod to Nova Scotia it washes an extremely long and varied coast. We have dredged and seined themes from the activities, concerns, organisms, vessels, and the past of this vast watery region of North America. We aim to be inclusive rather than exclusive, suggestive rather than factual, and stimulating rather than expert. Our hope is that your students will become more questioning, interested, and critical of watery concerns. We hope your use of these materials will add water back into our culture.

John W. Butzow

A Note on Measures and Genders

In this unit metric measures will be used. We wish to strongly urge the use of metric measures as part of our nation's change to the metric system. As educators, our duty is to assist the metric conversion.

A number of occupational words have as yet no generally used non-sexist equivalent. We have therefore retained use of the terms fisherman and lobsterman for either sex.

Throughout this unit, weight, length and the other statistics used are the "best guess" with the available data. It is difficult to present 100% accurate data as all data is tentative.

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Shark Dissection Diagrams

The broad purpose of marine education is to develop a marine literate citizenry; that is to educate our students about the fundamental importance of the connections of human culture to the marine and aquatic environment. The general purpose of the marine education infusion units in this series is to provide teaching materials to make this broad purpose possible for middle and junior high school teachers in Northern New England. The special purpose of "Do You Know Our Marine Fish?" is to make available teacher-tested ideas and activities for use in your classroom and in your field trips to the ocean where the fish live.

The important concepts in this unit are the diversity and complex interactions these organisms make on the marine environment. Specific objectives are given for each activity, but bear in mind two general objectives. Students should develop improved knowledge and increased appreciation of the beauty and complex interrelatedness of marine fish as important organisms in our sea.

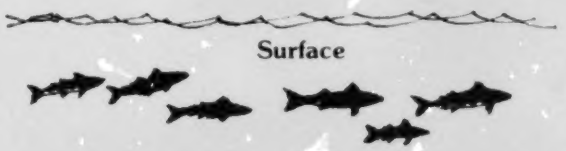
What Makes A Fish, A Fish?

Several key characteristics will help to distinguish fish from other animals. Fish normally live all their lives in water. A few fish, the walking catfish and eels, occasionally leave the water to move over the land. Another characteristic of fish is that they usually have scales. Scales are outgrowths of the skin and there are several different types. Some examples are placoid, ganoid, ctenoid, and cycloid. Fish also have gills for respiration and occasionally "lungs." The fins on a fish are appendages specialized for aquatic locomotion.

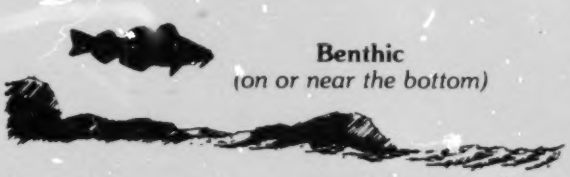
Fish are the most numerous of the vertebrates. They make up 43 percent of 37,600 species of recent vertebrates. Ichthyologists (fish scholars) estimate the number of recent fish species to be between 15,000 and 17,000, with the possibility of 40,000 different species. These numbers are large when compared to such groups as mammals which have 4,500 species; and this number includes people. Although there are many species of insects, none of those well-adapted animals can match the degree of diversity in sizes and shapes of fish. Fish range from the smallest animals to monsters 50 feet long. It is really no wonder why there are so many different kinds of fish when their long existence on earth and the extent and variety of their habitat are considered. They antedate people's ancestors by 400 million years and most other vertebrates by 100 million years. With more than 70 percent of the earth's surface covered by water, fish range from approximately 3 miles above sea level, in mountain streams, to nearly 7 miles beneath the sea. Fish occupy habitats from below freezing waters to hot springs, and from fresh water ponds to salty seas. Fish also have diverse reproductive cycles and several examples of these are included.

Depending upon the fish type, fish may live anywhere in the water. For example, ground fish are benthic or bottom dwelling.

The Water Column

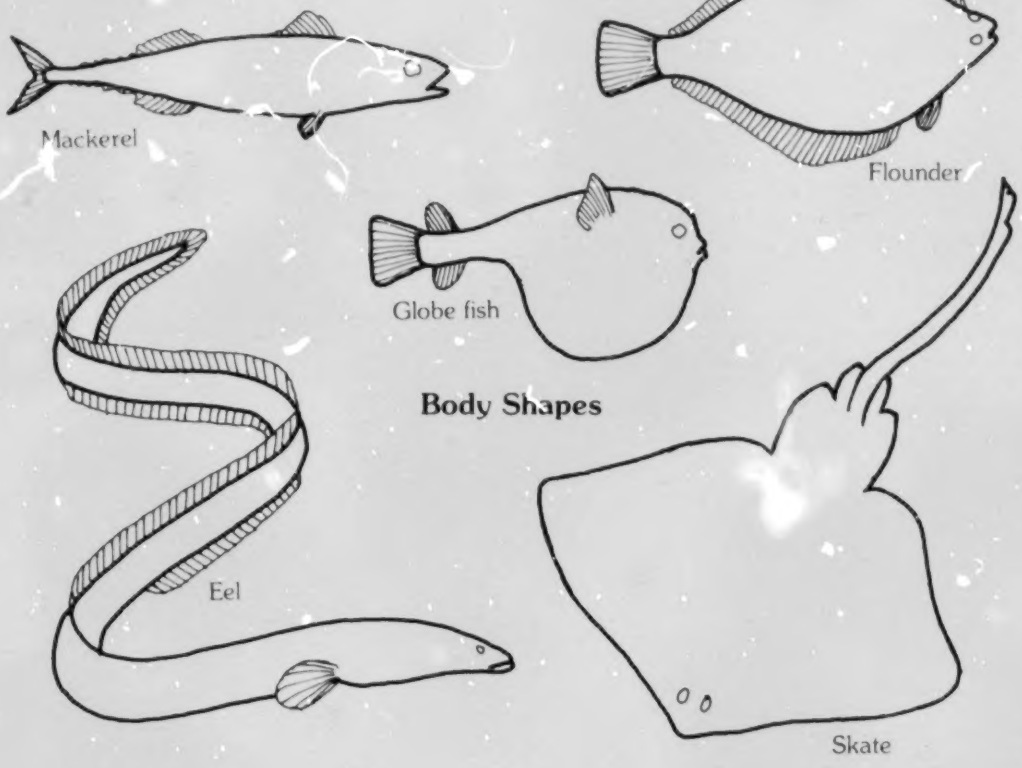


Pelagic
(in the water column at any level)



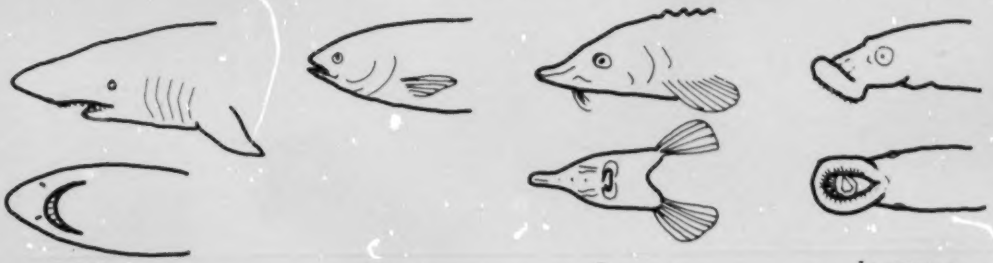
Benthic
(on or near the bottom)

Fish Shapes

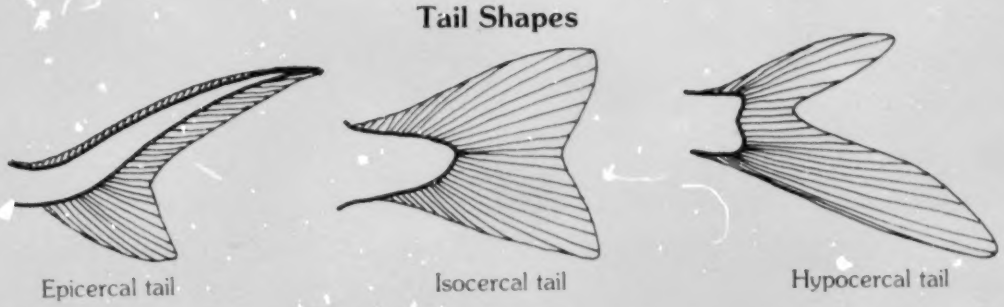


Body Shapes

Mouth Shapes



Tail Shapes



When speaking of specific fish, it is more precise to use the Latin name (including genus and species). The use of the Latin or scientific name avoids the error of speaking about the wrong fish. Using the common name, which may not be the same common name someone else uses, can lead to confusion. The same fish has only one scientific name, but may have several common names. For example, *Clupea harengus* is the scientific name of the herring. Its common name is herring, but it may also be called sardine, brit, or sperling. You may want to discuss this with your students.

Fish Shapes

Fish come in many diverse shapes and sizes. Some fish appear triangular, rectangular or cylindrical in shape and others, round, flat or elongated. With time a fish may even change its shape, and certainly its size. The reason for different shapes and sizes is adaptation to environmental stresses. Depth, bottom type, and type of food are examples. Under differing conditions, fish have need of different shapes and sizes. For example, the triangular-flat shape of a flounder is useful for bottom-dwelling life. With this flat shape, the flounder camouflages with the bottom. The cylindrical shape of the shark is useful for speed. The shark lives in the middle of the water column and depends on speed and size to catch its food. Some fish, such as the puffer, are round and upon the approach of a predator expand to much larger proportions by taking in large quantities of water through the mouth. The eel, a scavenger, has a snake-like body and lives on the bottom; where it uses its body shape to get into crevices. As the eel does not live solely in the water column, like the mackerel, it can swim more slowly and does not require the streamlined shape of the mackerel. Fish are often small because they need to hide from their predators to avoid being eaten.

The shape and size of each fish depends on where and how it lives. Even the shape of the body parts, such as the tail and fins, is due to the way a fish lives. A long pointed beak with sharp teeth is useful if the fish eats other fish, but it would be practically useless if the fish ate organisms out of the mud. In the same trend, a shark's tail is useful for long distance swimming in the ocean, but it would not be as helpful for prowling around crevices where eels live.

Classes of Fish

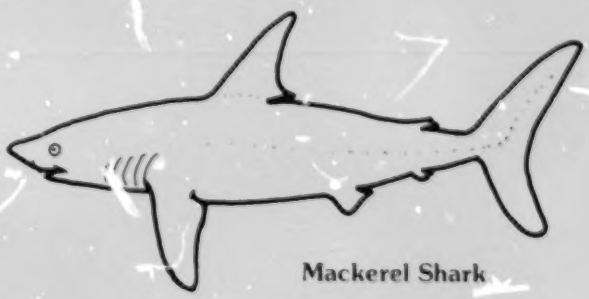
There are three classes or biological groups of marine fish. These are Agnatha (no jaws), Chondrichthyes (cartilage skeleton), and Osteichthyes (bony skeleton). They are so arranged because of the unique biological advantages each one has.

- **Jawless** or Class, *Agnatha* include the lampreys and hagfish. Both are parasitic and will not be considered in depth in our study.
- **Cartilaginous** or Class, *Chondricthyes* include sharks, skates, and rays. The cartilaginous fish have a predominately marine existence, a skeleton made of cartilage, placoid scales, no individual gill covering and no "lungs" or swim bladder. Instead of an individual gill covering called the operculum, this class, with the exception of the subclass *Holocephali* (ratfish), has five external gill openings.
- **Bony** or Class, *Osteichthyes* are those fish with a skeleton made of real bone. They demonstrate several types of scales (except placoid), and an individual gill covering called the operculum. They may be marine or fresh water, and they usually have lungs or a swim bladder. Cod, haddock, and pollock are representatives. A look at representatives from the **Cartilaginous** and **Bony** fish groups follows:

Cartilaginous: Sharks

Living off our coasts are sharks and their kin that have been the subjects of many myths and misunderstandings. Many people consider the shark "primitive," "dangerous," a general "menace" to our fishermen. Although these ideas may be partially true, it is necessary to examine these interesting animals more closely before we "rest our case."

Sharks have always been on people's minds — certainly since historic times. There are numbers of paintings, legends, and descriptions of them from all over the world. In spite of the great interest in them and the comparative studies in anatomy and the research on their physiology, surprisingly, very little is known about their natural habits. Perpetuated myths about these animals and films such as Jaws I and II do very little for the citizenry other than whet their appetites for drama and increase their fears of our watery world. Many people cannot separate "fact from fiction" — real from unreal.



Mackerel Shark

Presently scientists have documented the number of shark species to be more than two hundred forty. There may be more. Of these, about one percent are really termed "maneaters." Since people do not fully understand sharks' habits, the best we can do is describe the animal as unpredictable. Without reliable information, people often

consider many sharks as potentially dangerous or harmful; but that does not mean that these fish single out people as prey. It is most likely by accident that humans are attacked by sharks. As cited by one report, shark attacks are very rare. The chances are equated to that of being struck by lightning or being run over taking a walk to the beach.

The idea that the sharks are a menace to society is not so much founded by behavior, as it is founded by the sharks' ominous appearance. These fish are well adapted to their predatory existence. Their long tenure of 350 million years, in spite of fierce competition for food and living space, supports this claim. Powerful and swift sharks and their relatives, the rays and skates, are anatomically unique when compared with other animals of the sea.

Primitive is not an appropriate description of this fish because it is considered both more primitive and more advanced than some of the so-named higher bony fish as the Atlantic sea bass or rock cunner. The bones of sharks are composed of cartilage. When it dies, this substance quickly decomposes. That is why shark skeletons are rarely washed ashore. Occasionally, the skull of a dogfish or the hard enameled teeth of other sharks are found in the flotsam and jetsam.

Dogfish

As an example of a shark, we will look at the spiny dogfish, *Squalus acanthias* (market name, Greyfish).

Description of the dogfish includes a small-slender shark quickly recognized by its sharp spines that protrude along the forward edge of the two dorsal fins. It is grey in color and has white spots that run from the pectoral fin to the pelvic fin with several at the base of its dorsal fins.

Dogfish Shark

The first dorsal fin is a rounded triangle with a trailing edge that follows close to the back and also has the smaller of the two spines at the leading edge. The second dorsal is more toward the tail and less triangular with a similar-trailing edge and the larger spine is almost as high as the fin itself. The pectoral fins are longer than the first dorsal and similarly triangular and rounded, originating just behind the gill slits. The pelvic fins have a trailing-tapered edge behind their highest point and are located between the dorsal fins in profile. The caudal fin is broader on the upper half and quite stubby on the lower half with both halves rounded at the tips.

The dogfish has teeth that are very small and pointed, and grow in a sideways direction, in rows, along its jaw. In size, the dogfish average 3.0 to 5.0 kilograms and 1 meter in length.

Life Cycles of the young dogfish are 18 to 22 months in length and the young are usually born on the offshore wintering grounds, though some may be born in late spring and summer, inshore. The female carries a litter of about four to six pups and they average between 15.0 and 25.0 centimeters in length.

Habits of the dogfish are not always consistent. They show patterns of migration, though not always by definite times of the year. They appear on the offshore banks by early spring, but do not find their way into the shoaller areas of the Gulf of Maine until June and July, lingering until September. When they move into an area, they do so by the multitude, often moving in packs by year class. Dogfish plague the gillnetters, longliners, and trawlers. Because of this, they have been of great frustration to commercial fishermen. Until recently there has been no market for them. A voracious feeder, the dogfish eat squid, crabs, worms and almost anything smaller in size. They are very destructive to much of the more traditionally-marketable species of fish, both pelagic and ground fish.

Commercial Fishing Methods include any hook and bait systems, gillnetting or otter trawling. Other larger sharks are also marketed as a by-product to supplement the regular catch in the Gulf of Maine. These include mackerel (porbeagle), mako, and basking sharks.

Bony: True Fish

The *Osteichthyes*, or bony fish, form the second main class. Bony fish may be pelagic, such as mackerel, tuna, and herring. Bony fish may also be groundfish (cod, haddock) which live close to the bottom. Groundfish are one of our best sources of commercial fish. Bony fish may live close to the shore (smelt), on the bottom (flatfish), on the surface (herring), or pass back and forth from fresh to salt water (eels, alewives, and salmon).

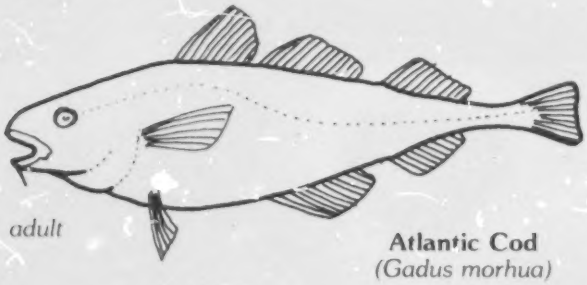
Throughout history, people have been intrigued by fish. Pisces (fish) was a constellation in the heavens. People have been able to tell the time of year by which bony fish was caught. The smelt and alewives meant spring with tuna, and summer-flounder meaning summer. Mackerel signified the last of the summer, frostfish the fall, and winter-flounder were caught in winter. People were more likely to catch certain fish according to the particular season.

Bony fish, because of their more advanced anatomy, are often termed the "true fish." In an evolutionary sense, a skeleton of bone is considered more advanced than one of cartilage. The gill covering, or operculum is considered more

advanced than gill slits with no covering. When you think of fish, more often than not, you think of bony fish.

Cod

The Atlantic Cod, *Gadus morhua*, is an excellent example of a bony fish familiar with the Maine waters.



adult

Atlantic Cod
(Gadus morhua)

larva

Description of a cod includes color, body structure and size. The color is olive green or brown on the back and sides; the belly is white. There is a white or pale lateral line on the sides and vaguely-edged dark spots along the back and sides from nape to tail, not on the belly. It has a single barbel on its lower jaw — the upper jaw extends beyond the lower. The tail fin is almost square. Market size cod are about 2.0 to 6.0 kilograms. They may get as large as 45.0 kilograms and 168.0 centimeters in length.

Life Cycle begins with spawning occuring in winter months from about the end of November to the first of April or as late as the first of May in the Northern Gulf of Maine. Spawning usually takes place in depths less than 90.0 meters, in temperatures of about 2° C, and eggs are produced at about three million per adult female. Larvae (immature stages of the fish that often look different than the adult form) continue to float and drift with currents heading down the coast for about 14-30 days before becoming pelagic feeders and growing to small-fry proportions, feeding on copepods and other pelagic larvae forms. The frys take to bottom as they grow bigger. The areas of bottom which they are over have suitable feed, usually an upwelling area of relatively shoal water, such as a fishing bank (see map on page 8).

Habits of the Cod depend on food and bottom type. Moving cod tend to congregate by size and often travel in the pelagic range of water, hunting out good bottom, squid or small herring. Their movement is not to be considered migratory but can also be caused by seasonable temperature changes in the water. These fish move as groups, but do not act as definite "schools" though this term is often used, caused by lack of food or predatory harassment.

When in residence, cod tend to stay within two to three meters above bottom types of ledge, rock, slopes of shoals, pebbly bottom or gritty-clay shell bed. In March and April they reside over soft-mud and sandy-bottom. They range from near shore depths (several meters or less) to about 450.0 meters, in temperatures colder than 10° C. In these waters their main diet is mollusks and crustaceans but they will gobble up squid and almost anything else in a pinch.

Commercial Fishing Methods include jigging (mackerel), longlining (haddock), gillnetting (herring, sharks, pollock), purse seining (herring), and bottom otter trawling (halibut). The fish in parentheses include other fish caught by the same method. Some are trapped in midwater trawls or pelagic gill nets, but this is because they were in transit or paralyzed by fear, and it is not common

Fish That Migrate

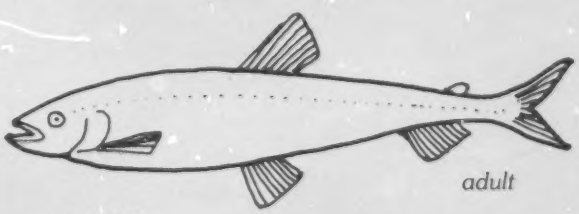
The previous two species were examples of marine fish. The sea is also a habitat for fish which spend only part of their life cycle in the sea. These fish are categorized as anadromous or catadromous fish.

- **Anadromous** fish live in the sea and mature to adulthood. They enter and ascend freshwater to spawn. The young hatch and live there until they reach the stage when they can return to the sea.

- **Catadromous** fish mature to adulthood in fresh water. They descend to the sea to spawn. The young hatch and live there until they reach the stage when they can return to freshwater. A look at representatives of both groups follows:

Anadromous: Smelt

The Smelt, *Osmerus mordax* is a good example of an Anadromous fish.



adult

Smelt
(Osmerus mordax)

larva

Use this scale for measuring fish specimens.

Description of the smelt includes a slender shape with a long pointed head and large mouth. The tall dorsal fin is located above the ventral fin in profile and is relatively short in length. Behind the dorsal fin and above the rear section of the anal is a small adipose fin. The smelt has a forked tail.

The smelt is usually olive green on the back and sides. It has a broad silver strip that runs laterally and it has a silver belly. The average size is 18.0 to 23.0 centimeters and it weighs between .03 and .1 kilograms.

Life Cycle begins in fresh water. Spawning occurs between March and May. Eggs are produced at 10° C - 14° C. The average female produces 40-50,000 eggs which sink and stick together in clumps. They hatch in 8 to 27 days, depending on the temperature.

When the fry reaches 25.0 to 50.0 millimeters in length, it returns to the estuarine environments. It reaches maturity after its third spring (2 years old or more).

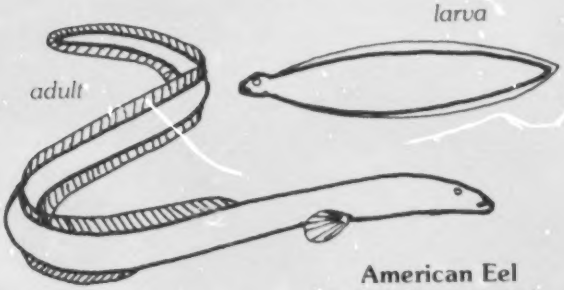
Habits of the smelt vary. They live close to shore in harbors or estuarine situations according to year class (a group of fish all born in the same year). They feed on small shrimps, worms, and small fry of herring, mummichogs, and alewives. They also eat small mollusks and small crabs. The young feed on minute pelagic crustaceans after they return from spawning ponds and streams.

Commercial Fishing Methods include netting in streams during spawning season and also handlining through harbor ice in winter.

Catadromous: Eel

The American Eel, *Anguilla rostrata,* is an excellent example of a Catadromous fish.

Description includes a long-round shape that resembles a snake. The skin is rich with mucus



American Eel
(Anguilla rostrata)

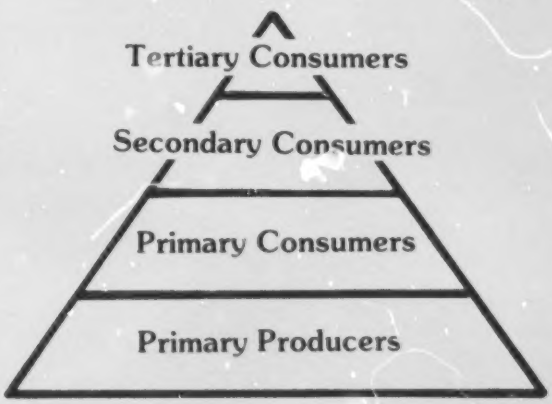
giving the eel a slimy-slippery texture. The tail has a long continuous fin going around it which is the anal, caudal, and dorsal fins united. The eel also has pectoral fins, a beak-shaped mouth, and a distinct line going down the side of the body. The mature female eel may reach 180.0 centimeters in length. The male may grow to 45.0 to 60.0 centimeters in length.

Life Cycle begins with spawning in the sea. In the fall, the mature eels leave freshwater and return to the Sargasso sea. There, the eels spawn. Each

female produces up to 20 million eggs. In mid-winter spawning adults die and the larvae (Leptocephali larvae) hatch in the shape of a wide transparent ribbon. In the fall, the larvae drift with the ocean currents to the shore. In the spring the females ascend the freshwater to mature in inland waters, while the males remain to mature in brackish water. After both have spent the winter before in metamorphosis, they become "glass eels" or "elvers" which are shaped like the adults, only transparent. The "elvers" become dark-brown when they approach fresh water. They mature and become spawning "silver" eels in freshwater systems for 4 to 9 years until ready to complete their catadromous life cycle.

Habits of the eel are relatively simple in nature. The eel feeds on whatever it can during the night. During the day, the eels hide under whatever they can find for cover.

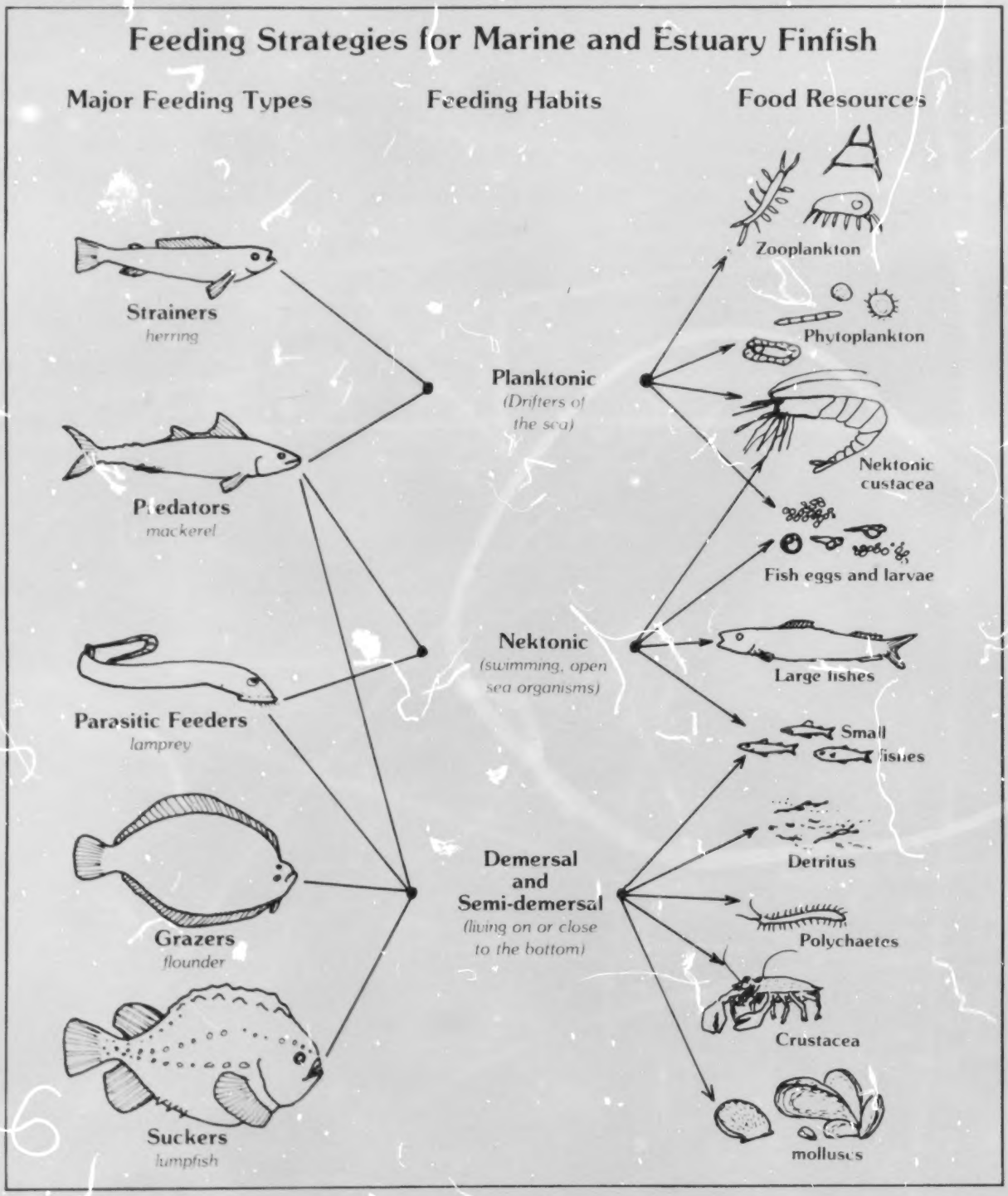
Commercial Fishing Methods include spearing techniques, eel pots, and weirs.



Fish Feeding

Fish feeding occurs in different ways in on many organisms. In the pyramid structure of the food chain fish may enter at any level above the base. Algae and phytoplankton, the producers, make up the base.

Fish are the consumers stated as the major feeding types on the diagram. The "feeding habits" list where the fish feeds, while the food resources list the types of things fish eat. By following a feeding type of fish across the chart you find the habit or where the food is in the water, as well as the actual food organism.



Fishing Grounds

Commercial Fishing

Historically, fishing has been of great importance to Maine people. Fishing was of economic value to the first settlers as it is to people today. In the early 1600's fishing was organized commercially by Western Europeans for the first time. Temporary settlements soon became permanent with the establishment of Maine's fishing grounds.

Numerous kinds of fish are in demand commercially. Fish that were undesirable in the past are sought after in today's market. The shark is an example. This fish, thought of as undesirable for years, is now a popular item in the fish market. The commercial groundfish today are mainly cod, haddock, hake, pollock, and cusk. The flatfish (flounder and halibut), sardines (herring) and alewives are also marketed.

Fish can be marketed in several ways. The quickest way is to sell fresh fish directly off the boat. Fish spoil quickly, however, which is the reason for processing. Canning provides a suitable means of processing for sardines and other species such as mackerel. Freezing preserves fish, not only in the raw form, but in such forms as breaded, filets, and steaks. Drying and smoking are further means of preparing the fish for a marketable form to insure freshness for consumers throughout the country.

One reason for today's increased market is the extension of the coastal economic zone up to 200 miles. A subsequent reduction in foreign competition has helped Maine go from 3% of the total New England landings in 1976 to 17% of the total New England landings today (1980 data).

1980 Catch Statistics

Landed Value To Fishermen	Kilograms/ Year	Dollar Value
Cod (Large)	2,218,429.0	1,071,529
Flounder (Dab) (Large)	4,555,201.0	3,865,261
Alewives	1,199,434.0	170,169
Pollock	5,833,016.0	2,097,191
Cusk	722,391.0	288,544
White Hake	2,715,839.0	843,142
Haddock (Large)	2,692,524.0	2,543,853
Shark (Dogfish)	619,063.0	93,474

A town is considered an important fish port if it has certain facilities and characteristics. Some of these are the availability of refrigeration and ice (a necessary ingredient for preserving the freshly caught fish), the ready-access to fishing grounds nearby (important, when considering energy costs), a good harbor, an efficient fish pier, and in the case of sardines — a cannery. The town that meets these conditions is more likely to continue being heavily used. A few examples of towns that are good fish ports are Portland, Jonesport, Eastport, Bath, Belfast, and Stonington.

In Maine, at this time, the coast from Portland to Jonesport has the largest area of fishing bases. Eventually, that area will expand to Eastport. Maine has more fishermen now than ever. One possible reason for the increase of fishermen, besides the availability of fish and the 200 mile coastal extension limit, is that Maine is a unique state where people traditionally view the coast as a working coast and not just a recreational coast. Economically, Maine does not have the economic resources which other states do, and so the state usually turns to its natural resources of mining, lumbering, and fishing.

Maine's fishing industry is becoming such an economic area of expansion that several controversies are of major concern. One is that Maine now ships most of its fish to Boston for auction. The fish, caught by species goes to the highest bidder at wholesale prices. An industry in Massachusetts can then buy the fish. Later, the fish are distributed to a Massachusetts production facility for processing. The finished product, whether it be Maine or Massachusetts fish, is then shipped throughout the country, as well as back to Maine to be sold at retail price. Many people in Maine would like to have the fish auction in Portland; whereby, encouraging more processing plants to locate in Maine. The increased industry would provide jobs and monetary returns for the State of Maine and not Massachusetts. A further benefit would be the reduced prices Maine consumers would pay for fish products.

Another area of concern is the oil production in George's Bank. The Georges Bank produces 15% of the world's fish. That percentage signifies the importance of fishing in this area. The oil returns are nonrenewable and would provide only enough oil to operate the United States for several days. The controversy over the Georges Bank is one of concern over the possible damage that could be done by oil production to the fishing grounds. It becomes a question whether the oil is worth the risk.

Yet the fact remains that Maine is expanding the fishing industry in record attempts and time. The future of Maine's fishing industry is a bright-shining star on the horizon. Through the medium of informed voters, Maine and other states will solve whatever controversies and problems occur.

Recreational Fishing

When one is not fishing for profit, fishing can still provide a wealth of returns. For the sports fisherman, the returns of the sport touch one's appreciation of nature. Fishermen on the waters, along the coastal waters, on the rivers and streams, on the ponds and lakes, and even under-the-water scuba diving enjoy catching a variety of species. People of all ages can rapidly become proficient at the sport of fishing by mastering the skills necessary to perform the tasks. The tangible and intangible returns can be culminated in a most enriching manner when you can eat the days catch.

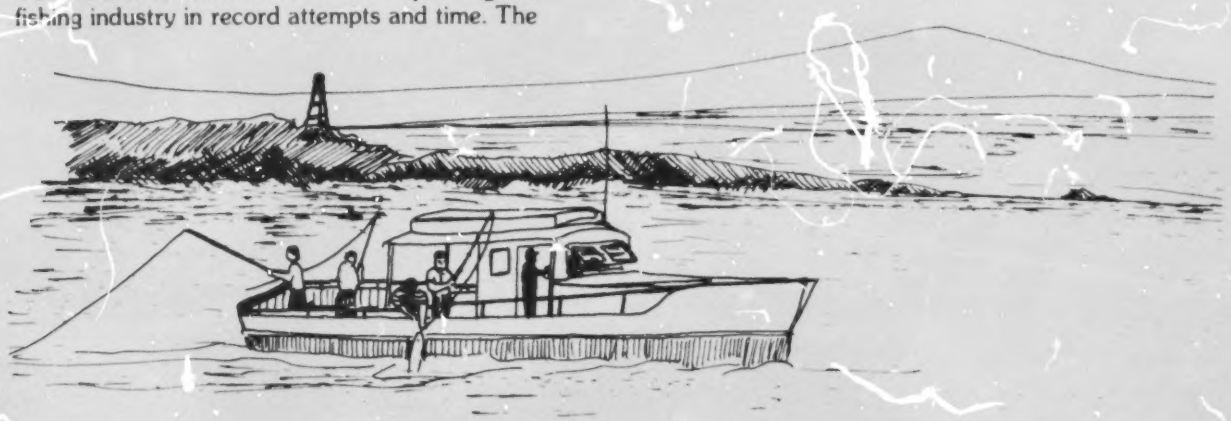
"Party boats" and other recreational boats take people fishing for sport. At a fee, the rods, reels, and bait for the day are provided. With the help of the fish and an experienced Captain, several species of fish (cod, haddock, shark) may be caught. You might contact a charter boat in your area for an exciting field trip.

You do not need to go out in a party boat to catch marine fish. Fishing off piers provides the opportunity of catching several species such as mackerel, pollock, flounder, skates, and sculpins. If you are in the right place at the right time, you may catch a nice meal.

The data is from 1975 and is only an estimate of dollar value in Maine:

Private boat — $24 million
Charter boat — Almost $2 million
Shore — $28 million
Party boat — $2.5 million

These figures are tenuous due to the current lack of concise data due partly to the difficulty of accurately knowing how many boats and individuals are really involved in recreational fisheries.



Deep-Sea Fish

One of the little-known areas is the realm of the deep sea fish population. In the deep-sea, fish must endure one of the most stressful environments on our planet. Perpetual night, incredible pressures, and a scarcity of food, make the deep-

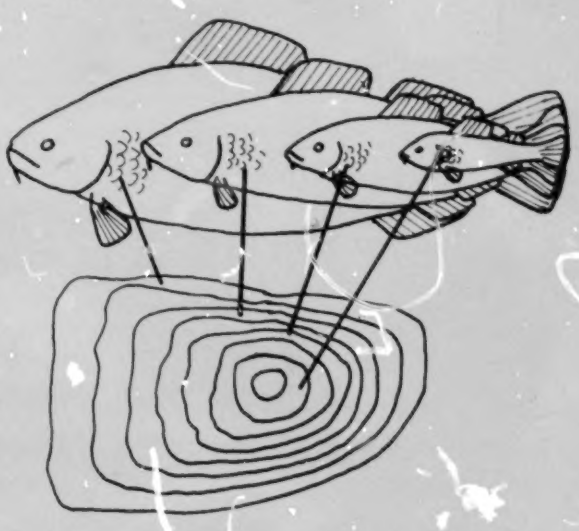
sea environment incredibly difficult abode. Yet, there exists in the depths, fish capable of enduring and thriving under those conditions. To cope with perpetual night, some fish manufacture their own light. Their eyes may reduce in size, because there is not much need to use them. Angler fish may have their own "bait" (an outgrowth of a dorsal spine resembling bait) dangling in front of their mouth. Their bodies are designed to withstand the pressure and the fish are predominately carnivores. Males may become reduced in size and parasitic to the female (angler fish). The deep sea fish, evidenced by their habits and adaptations, are a most interesting assortment of fish.

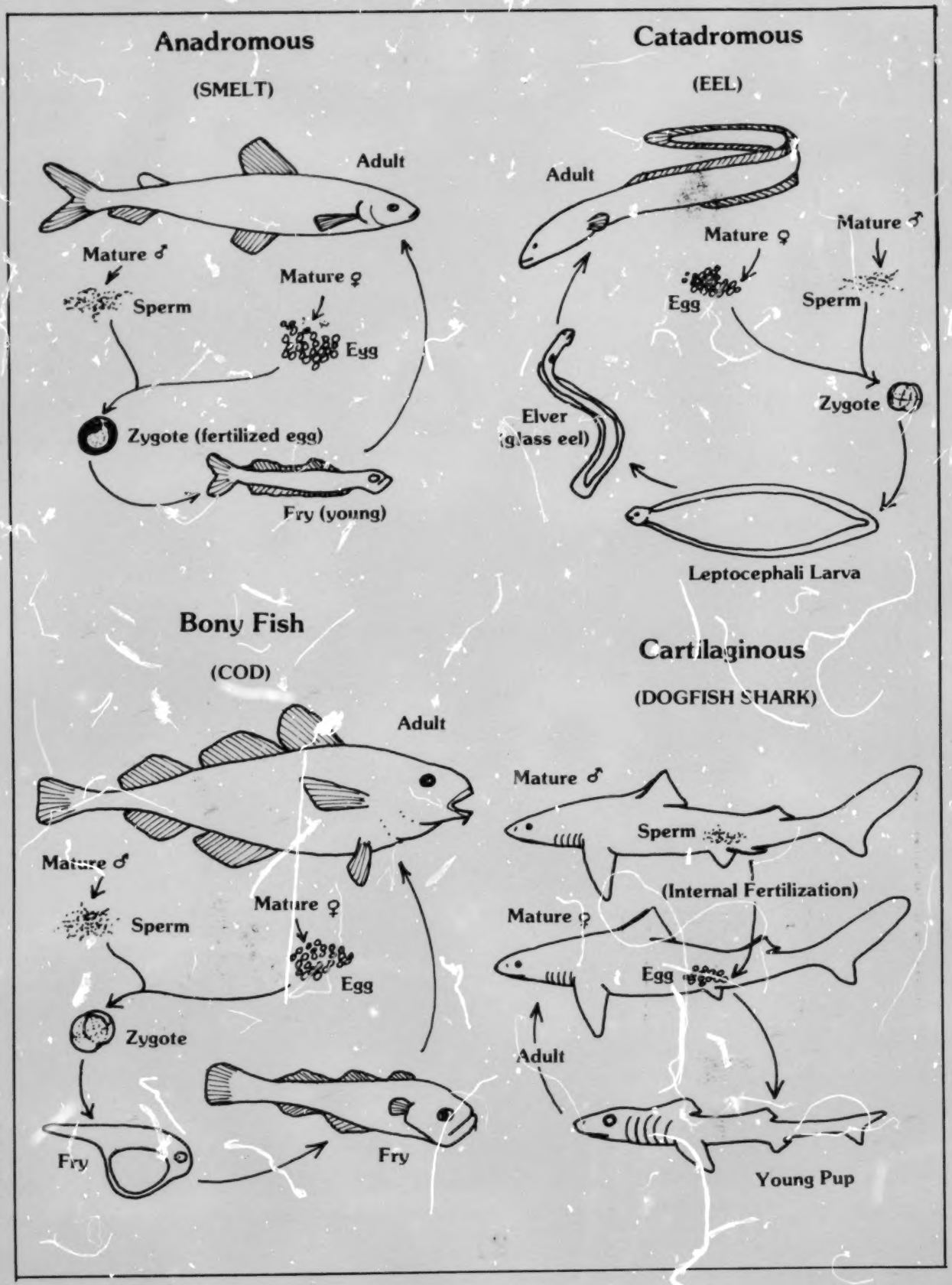
Fish Aging and Growth

The age of a fish is important not only to the fish, but to people as well. Fish grow as long as they live; even though, as they grow older, growth slows down.The skeleton of a fish grows similarly to the way a tree does. The skeleton grows outward from the center in concentric rings, and this provides a way to tell how old a fish is. You simply count the rings. A method used more often than skeletal counts is scale counts, because it is easier to get the scales. The scales grow in the same way as a skeleton does. Variations in the growth rings occur when something happens in the fish's life. For instance, when food is scarce for a few months, the rings show the effect of slowed growth. The conditions show on the rings; they are growth dependent.

Using the age information of each fish you can tell how old a fish population is. The age of a fish population provides data for decisions about how to regulate the fishery ensuring a continued healthy fish population

Several agencies at different government levels are responsible for ensuring healthy fish populations. Nationally, the Department of Commerce, NOAA (The National Oceanic and Atmospheric Administration) has the Bureau of Commercial Fisheries and the Marine Game Fish Research Program. In 1976 when the 200 mile limit (extending the nation's jurisdiction of marine waters to 200 miles from shore) was enacted, there was also a clause charging regional areas to form management councils for fisheries. From that clause came the New England Fisheries Management Council. The New England Fisheries Management Council makes policies from the scientific and socio-economic data that regulate fishing. Examples of some regulations might be the Council setting net-mesh size for selective fish capture, and the regulations governing closure of spawning areas. At the state level, within the state's marine jurisdiction of three miles, the Department of Marine Resources and the Department of Sea and Shore Fisheries regulate fishing. If the state's regulations are not equal to, or are more stringent than the New England Fisheries Management Council, the New England regulations apply. Fortunately, the state attempts to set adequate regulations. At whatever level, the basic premise is that in order to ensure a healthy, renewable fish population, there must be sound judgments made for proper regulations. One way to continually provide data for such judgments is to have biologists study fish populations.

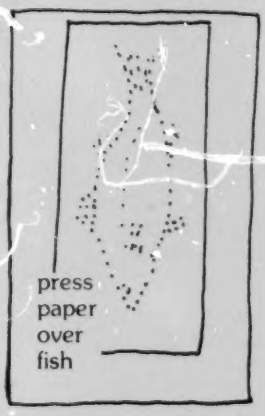



Anadromous
(SMELT)
Adult
Mature ♂
Sperm
Mature ♀
Egg
Zygote (fertilized egg)
Fry (young)
Catadromous
(EEL)
Adult
Mature ♀
Egg
Mature ♂
Sperm
Zygote
Elver
(glass eel)
Leptocephali Larva
Bony Fish
(COD)
Adult
Mature ♂
Sperm
Mature ♀
Egg
Zygote
Fry
Fry
Cartilaginous
(DOGFISH SHARK)
Mature ♂
Sperm
(Internal Fertilization)
Mature ♀
Egg
Adult
Young Pup

Gyotaku

1

2



3

4

Fish in the Arts and Crafts

Creative Writing, Poetry*

Haiku is a type of poetry invented by the Japanese. The structure of the poem is a seventeen syllable verse. In the verse there is the use of a seasonal word referring to some particular event. The lines are arranged with five, seven, and five syllables in each line, respectively. Rhyming is optional, with a subject matter of nature and season. When writing Haiku do not write directly about such things as ugliness or joy, but write about things for which you feel deeply. While writing, carefully choose the right word for the particular feeling and be brief by adding only a seasonal word. When written, the poem will be subject to different interpretations. You suggest the idea you want; but let the reader interpret it. Keep a sense of the present and immediacy in the poem. Use imagery to reinforce your mood in the poem. When writing the three lines answer the questions where, what, and when respectively in each line. Once written, read your poem aloud to someone else, as all poetry should be read aloud. Remember, in Japan the poets who wrote these poems were called friends of moon and winds.

An example of a poem is:

THE SHARK AND THE CRESCENT MOON

The crescent moon gives slender light
Yet reason enough for the shark.
To hide his head tonight

From the book: Little Pictures of Japan
Edited by: Olive Beaupre'
1925 by the Book House for Children

*** A special thank you goes to Professor Rosemary Salesi of the College of Education at UMO for her notes making this activity possible.**

Gyotaku -- Japanese Fish Printing

Gyotaku is an ancient Japanese method of recording fish catches and obtaining information. It is a simple and inexpensive procedure and a good way to gain an appreciation of the form and variety of fish. The procedure can also be used for making prints of other items such as shells, flowers, etc.

Materials:

- Paper (rice paper, newsprint, soft paper)
- Modeling clay
- Pins
- Water based ink (Pelikan Encre De Chine 17 black is best)
- Small paint brush
- A fish

Procedure:

Clean fish well with soap and water and dry well.
Place fish on a layer of newspaper.
Support fins and tail in extended position with clay and pin into place.
Paint one side of the fish with ink using a small brush. Spread evenly using a very thin film. Brush against the grain of the scales so ink will build up under them.
Carefully place paper over the fish and gently but firmly rub the entire surface. Be careful not to move the paper. Rice paper works best.
Lift the paper off being sure not to move the fish or smudge the print.

Fish In Literature

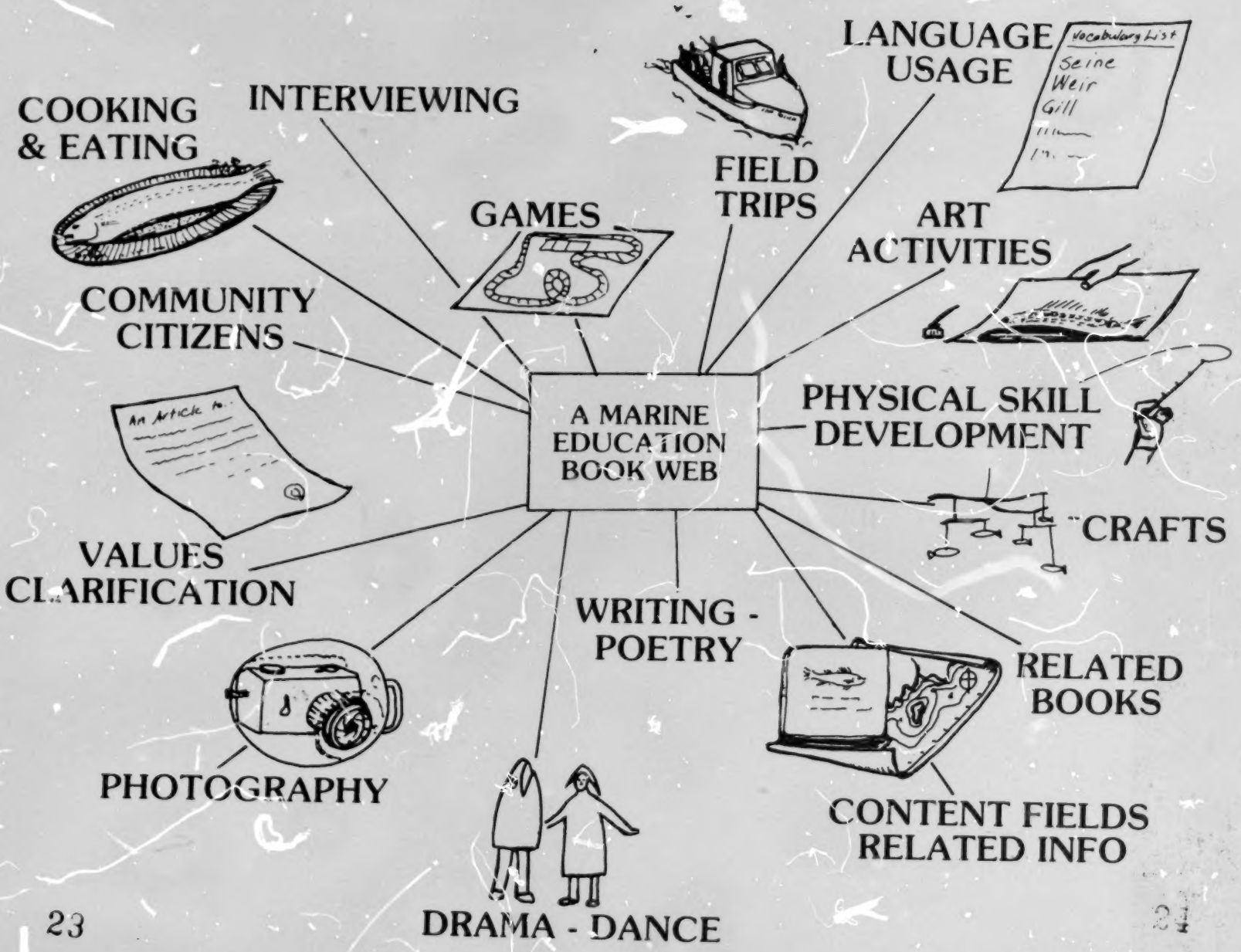
For this activity, using a book you feel the students will enjoy, create a literature web. A literature web uses a story as the basis and expands into many areas such as economics, biology, geography, mathematics, art, history and English. Activities and discussions about the areas are based on the story in the book. Included in the reference section are some books that may be used, or you can use another popular story. Some suggestions for consideration are:

Economics — have the students discuss how money and the work associated with it may be found in the story.

Biology — what are the biological relationships in the story? How are the characters alike, yet different?

Geography — where does the story take place? Where else could the story take place in the world and why could it?

Mathematics — use the story to involve the students with math by having them find areas of the story where numbers are important. What are


A MARINE EDUCATION BOOK WEB
COOKING & EATING
INTERVIEWING
FIELD TRIPS
LANGUAGE USAGE
Vocabulary List
Seine
Weir
Gill
GAMES
ART ACTIVITIES
COMMUNITY CITIZENS
PHYSICAL SKILL DEVELOPMENT
CRAFTS
VALUES CLARIFICATION
WRITING - POETRY
RELATED BOOKS
PHOTOGRAPHY
CONTENT FIELDS RELATED INFO
DRAMA - DANCE

the numerical relationships that the students can develop?

Art — have the students use characters from the story for art projects.

Literature Web for the book The Fish in the Castle by Dale Fife*

Economics — The family was on vacation. Have the students discuss the value of vacations. Make sure the students examine the monetary aspect of vacations with relation to why employers give vacations and how available money decides where and for how long people go on vacation. Have the students discuss where they would go on a marine vacation.

Biology — Have the students discuss how the tides influence when the grunion "run" to spawn. Have the students discuss advantages and disadvantages of eggs being deposited where the grunion do spawn. See if the students can think of other marine places fish deposit their eggs.

Geography — ask the students where the story occurs. Have the students discuss what is known about California in relation to geographical features such as weather (climate), coastline, currents, water temperature, and the availability of the grunion. Could the students find another place in the world where the grunion could possibly spawn and live? Discuss what factors could influence the grunion living where they do and how that helps determine where the grunion live.

Mathematics — have the students do a pyramid of numbers starting with an imaginary example of two grunion that increase in numbers over different time lengths. For instance, two grunion that mate give rise to four after two weeks, and give rise to eight grunion after four weeks. You might have the student practice word problems using cost/kilogram, and different fish species and prices such as you would find in the supermarket.

Art — have the students design or draw a picture depicting the grunion run. Models of grunion and sand castles would also be productive.

* Fife, Dale, *Fish in the Castle*. New York: Coward-McCann, Inc., 1965.

Plaster Fish

This procedure takes the form of a simple mold. It can be made more complex by casting a fish in a curved position, leaving its mouth open and adding plastic fins and a glass eye. You can even mold both sides of the fish for a more lifelike cast. The "mold" refers to the "negative" made from the fish. The cast is the life-like model made from the mold.

Preparation:

Keep the side that will be molded free from dirt and damage. If you wish to finish the cast in natural colors, it is best to take a color photograph of the fish while it is still fresh. Do not allow the fish to dry out, especially the fins and tail. If you freeze the fish, leave the side to be cast sitting up, and wrap the fish with wet cloth to prevent the fins from drying out and the possibility of freezer burn. Wrap in foil or freezer wrap.

Materials:

Plaster of paris, cardboard strips, pins, sand, shallow box, cheesecloth, coping saw, modeling clay, soap solution, plastic pail, cup, knife, soft brush, metal screen, scissors or snips, hanging wire, hammer, and shellac.

Source of Material:

Any hardware store.

Procedure:

Any slime must be removed in order to make a good cast. A fish that is coarse and scaly is a good choice (freshwater bass, sea bass, herring, flounder). A more slimy fish may require light scraping with a dull knife and slight drying. Male salmon and trout in the spawning season produce a great deal of mucus. This can be eliminated by cleaning with a diluted solution of vinegar and then rinsing with a solution of powdered alum.

Next, fill a shallow box half-full with clean sand and wet it. Cover sand with a double layer of wet cheesecloth. Make a depression in the sand, a little less than one-half the depth of the fish. Place the fish in a natural position and work sand up under the dorsal and anal fins, spreading them slightly. Pin the pectoral fins, if necessary, close to the body, as well as the anal fins. The mouth should be closed and may need to be pinned in place also. Build a shallow dam around the fish using either cardboard or aluminum strips.

Care should be taken to assure a good mixture when preparing the plaster of paris. Always add plaster to the water; about two pounds of plaster to a quart. Sifting results in a smoother texture; stir gently to get a bubble free mixture. Allow the mixture to set about ten minutes until it reaches a heavy fluid consistency.

Start at the tail and pour the plaster over the fish, covering it entirely to a depth of at least one-half inch. The mold may be reinforced with burlap. Plaster-saturated strips of this material should be layed on after the mold has set and then covered with an additional one-quarter inch of plaster. Allow two or three hours to set. The plaster will feel cool to the touch.

To remove the fish, roll the mold over carefully, remove the cheesecloth and slip a thin knife under the tail and gently work the rest of the body free. Do not touch the inside of the mold. Any mucus left in the mold will dry and curl as the mold cures. This will take 3 to 4 days. The plaster is cured when it is completely dry and no longer feels cool to the touch.

Casting:

Where the mold is thick as at the caudal peduncle, it is best to cut the mold from the back to nearly the inside edge of the mold. This will weaken it so that the cast will not be broken during removal of the mold.

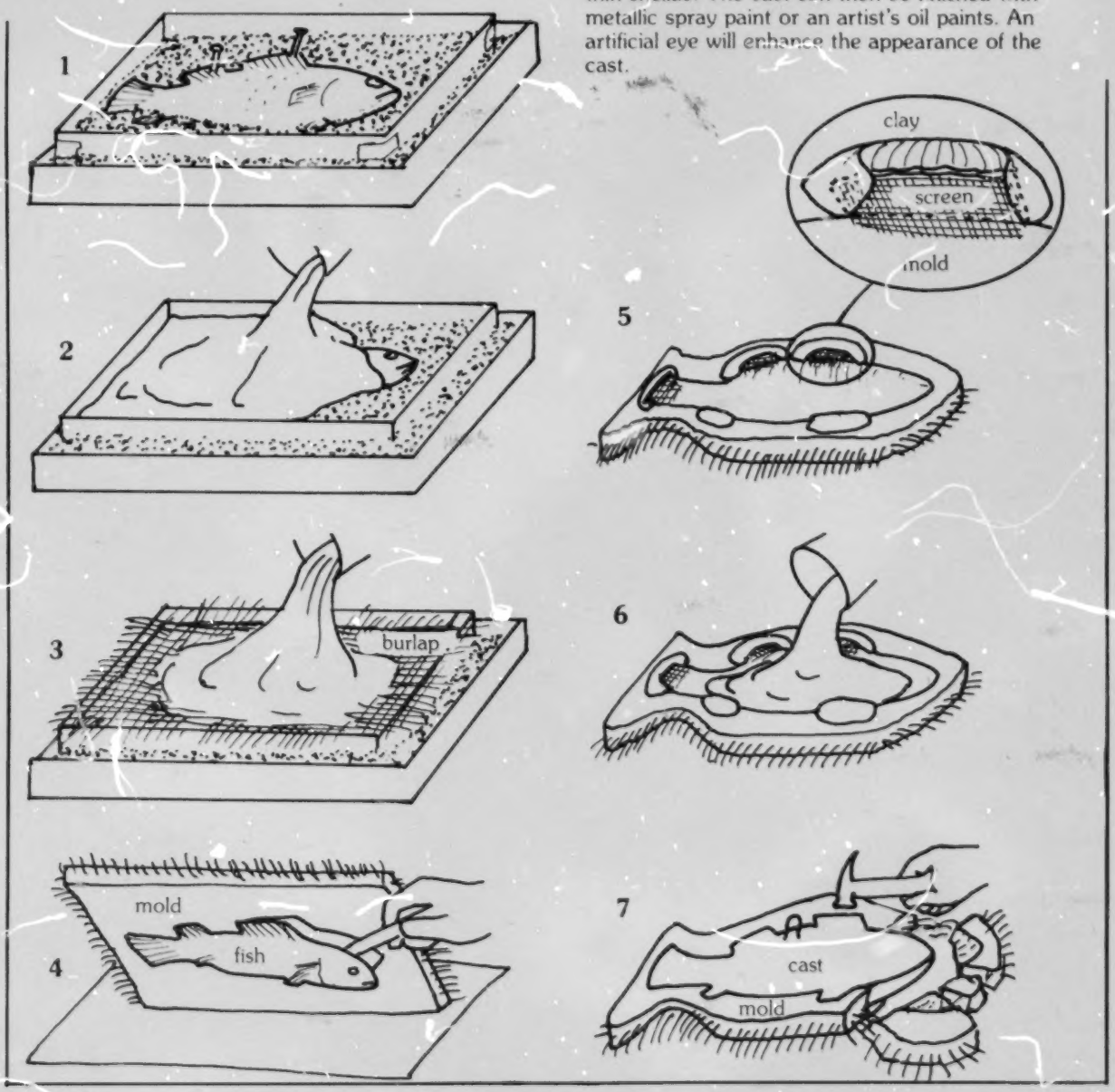
Build a dam with modeling clay along the edge of the fins outlined on the shelf of the mold. This will help strengthen the fins. Slant the clay well over the fin so the thicker base will be concealed. Cut metal screen in the shape of fins for reinforcement.

Carefully remove the clay dams and saturate the mold in water until bubbling stops. Brush two coats of diluted soap solution on the inside mold surface for a separation layer. Use a dry brush to remove any bubbles. Layers should be thin enough not to obscure any detail. If the soap is too thick, brush in a little water. Replace the clay dams and pour in the plaster into the fins and other elevated areas. Add reinforcing screens, or be sure plaster has flowed through them if they were in place before pouring. Add hanging hooks after the plaster has hardened slightly. Let cure 6-12 hours.

Once hardened, the mold may be broken away by tapping it lightly with a hammer or mallet. Care should be taken around fins and tail.

Finishing The Cast:

Broken pieces can be glued back when the cast is dried. Bubble holes and seams can be filled with plaster water. Seal with surface with 2 or 3 coats of thin shellac. The cast can then be finished with metallic spray paint or an artist's oil paints. An artificial eye will enhance the appearance of the cast.



Fish in the Kitchen

*For the next activities (**Purchasing Fish, What Finfish Do You Eat?** and **Fish Cleaning**) use the materials in the pocket to make copies to hand out to the students. Purchasing fish involves a trip to a local supermarket to evaluate fish products available to the consumer. The students will use the form in the pocket to collect the data which may be discussed and analyzed in class. Before going to the supermarket, the **What Finfish Do You Eat?** handout may be filled out by the students. A discussion of what the student's preferences are could follow. Once the preference handout and supermarket trip are completed, a "hands on experience" of cleaning fish is recommended. Try the activity yourself first, to familiarize yourself with the techniques involved. A possible checklist for student evaluation is also included in the pocket. The fish you use in cleaning and dressing may be any you can readily obtain. You could try some of the packing plants and local fishermen. It is better not to use fish as small as herring. After their activity is complete, the Eating Fish Activity is suggested as an integral component of preparing a seafood fish feast.*

Eating Fish

Discuss what "trash fish" means to New England people. How can these fish be used as a source of protein?

Many fish that are sold on market today were once considered trash fish (fish which are not commonly thought as edible). An example is the dogfish shark. This is often considered a pest to many fishermen. Today though, as much as 10,000 pounds of dogfish are caught by one Portland fisherman and sold on the European market.

Another example is the American Eel. The adults and elvers (very young) are collected by pots and nets along the Penobscot River. They are sold in New York and on the European market.

Have the students research various types of fish, especially unusual ones. Put on a seafood feast with such items as skate, dogfish, American eel, cusk, etc. Some of these fish may be donated by contacting fish packing plants around the state. The nutritional value of fish could also be discussed. Have students compare fish to red meats. A tentative fish feast is provided, but feel free to be imaginative.

A few recipes are included for your use. They may be found in the resource section. Try using these recipes in your seafood feast. See what seafood recipes the students are able to find.

A Tenative Fish Feast

Appetizer — Sardines and mustard

Chowder — Fish chowder with cod, haddock, eel, pollock and dogfish

Salad — Fish salad with poached cod and flounder chunks

Rice — Flounder tidbits on boiled rice with egg sauce

Entree — Deep fried haddock chunks
Deep fried eel chunks
Fried pollock filets with crabmeat stuffing
Sauteed dogfish marinated in lemon juice

Beverage — Include milk as a drink

Dessert — Irish moss pudding for desert

Methods of Cooking

Baking — the prepared fish is cooked for 20-25 minutes in an oven at 350° F (177° C).

Broiling — the prepared fish is cooked for 10-20 minutes in a broiler.

Pan frying — the prepared fish is cooked in a pan for approximately 10 minutes over moderate heat.

Poaching — the prepared fish is cooked in boiling water which is allowed to cool from boiling to simmer after brought to a boil with the fish in the water.

The above are only cooking methods. There are numerous recipes and ways to prepare the fish for the basic cooking methods listed. If you allow 10 minutes for each inch or 2.5 centimeters of thickness you shall obtain good results.

Fish Packing

A visit to a sardine packing plant will provide an excellent way for the students to grasp the concepts of fish packing. This is a field activity and planning and coordination are essential. If you have not planned a field trip before, reference to the section Pre-Trip-Planning in the unit **Have You Been to the Shore Before?** will be most helpful.

A cannery is a factory where fresh fish are processed. The processing consists of preparing the fish and then putting the fish in cans which are hermetically sealed (airtight). The fish can then be shipped without the danger of spoilage. Eastport was the first cannery town in Maine and America.

Freezing is another means of preserving fish. Until the invention of refrigeration, preserving fish was difficult. Fresh fish did not last long. Ice helped preserve fish, but only refrigeration could preserve fish, and only for a few months. The processing plants use cleaned and prepared fish in different stages of preparation for freezing. Fresh-cleaned fish may be frozen or fish may be processed further by breading the fish portions for freezing. There should be plenty of examples at your local supermarket.

The reference section provides some places you may wish to visit. If they are not convenient for your class, there may be another plant near you to contact.

In whatever way the fish is processed, an important part of the processing is cleaning. Using a sardine factory as an example, you find that the cleaning consists of cutting off the heads and tails. Yet, portions cleaned are not wasted. Lobstermen use the discarded heads and tails for bait for lobsters. Lobster bait needs no further preserving; the more it smells the better the lobsters like it.

Before going on the field trip there are several questions that will help focus the students on the principles of fish packing during your field trip. Upon your return to class discuss what the students experience.

a. Have the students discuss what technology was involved with the packing. Why are the cans hermetically sealed?
b. What employment opportunities are available for someone interested in the packing industry. How much education and training is necessary?
c. How do you know that the fish are suitable to eat once packed? Who is responsible for quality control?
d. What did you observe for working conditions?
e. How does the packing plant market its products? Who buys fish and where are the fish shipped? How are the products shipped? Would you ship them the same way and would you change the marketing? How?

Preparing Finfish Checklist

Use this checklist to evaluate the abilities of your students.

Activity	*Satisfactory*	*Unsatisfactory*
1. Identified equipment to be used a. Scaling knife or alternate b. Fillet knife or alternate		
2. Gilled and gutted finfish a. cut into area under chin b. cut belly cavity back to anal fin c. avoided cutting intestinal tract d. removed any visible fat e. removed kidneys and abdominal lining under running water		
3. Scaled and Removed Fins a. used scraping motion from tail to head b. removed fins by cutting ¼" along each side c. pulled fin away, from tail toward head		
4. Skinned fish a. cut skin, not flesh, along top of fish and around fins b. peeled skin away with pliers or fingers		
5. Filleted fish a. cut into flesh back of head at 45° angle to backbone b. turned knife and followed backbone to tail c. removed rib bones if necessary d. cut fillet away from tail		
6. Practiced good sanitation techniques throughout procedure		
7. Prepared fish correctly for storage according to directions given		

Fish in the Market Place

Making Models

A good visual aid for fishing methods is a model of a fish capture. Students could work in teams to make models of fish capture methods. Using scrounge able materials and pictures of models, have the students devise their own models. Creativity is the key.

Materials that will be useful for the models are toothpicks, glue, string, yarn, nylon stockings for fine mesh, onion bags for wide mesh, cardboard or styrofoam for the base, scissors, and posterboard for fish shapes. Have the students study the pictures of the methods and see if they can construct their own capture method model. When deciding what fish is caught by what method, refer to the checklist of common Gulf of Maine fish. Do not forget to see what personal finds and information the students come up with.

The pocket contains a handout master with examples for students concerning commercial fishing methods useful for the model making activity.

Trawlerman

The object of this game is to see how much money you can make on a trawler during a day's cruise. For twenty turns, each signifying units of time during a day, you sail your vessel to catch fish. Watch out for chance, as it may not be all smooth sailing. The game may go longer than a day if you so choose, by simply extending the turns around the board for each additional day. The game can by played by one or many.

Begin at the mooring. Each player throws the dice to see who goes first. The player with the highest number begins by throwing the dice and moving the indicated number of spaces. Landing, the player follows the instructions printed there. If you land on a space in the fishing grounds, you pick fish-catch cards as indicated. If a boat lands on a space already occupied, immediately roll again and go backwards. You only haul the trawl once per fishing ground. When the first boat reaches port again, all boats return automatically if you are playing only one "day."

At the end of the game each player totals their list and compares the weights for each species to the dollar value. Sum up the dollar value for each species to get a total. The player with the largest amount of money from landed fish is the winner. If you play the game alone you can see how proficient you are as a fisherman.

Your boat is one of 4,500 kilograms (10,000 pounds) and you have one day until you automatically go home to port to sell what fish you have. Good luck. You will need it. Remember, have each player keep a tally sheet. The game board and accessories will be found in the pocket.

What Is A Fish?

Fish Shapes (Invent a Fish)

Materials:

Modeling clay, paper mache, wire, string, yarn, balloons, construction paper, and other scrounge-able items.

Have the students invent a fish. Once they pick the fish they wish to make, the students will use their imagination and any scroungeable materials to make a model of the fish. The following is a list of types of fish shapes they may try. Whether the students use paper or clay, the principle is one of creativity and design.

- Invent a fish adapted (designed) for living on the bottom in sand or mud. It should be able to hide by burrowing under the sand or mud surface.
- Invent a fish whose appearance is so gruesome that other fish would be frightened and repulsed. The fish must be grotesque, yet able to swim and live on the ocean bottom.
- Invent a fish that can swim very fast. The fish would live in the water column eating small organisms in the water.
- Invent a fish that would eat other fish. Remember the fish must catch the fish before it can eat it.
- Invent a fish that would live between rocks or on a reef. The fish would eat whatever it could catch and would need to be able to move around rock crevices.
- Invent a fish that would eat clams or other organisms that live in shells.
- Invent a fish that would escape capture by jumping and gliding over the water's surface.
- Invent a fish that lives in very deep water and must withstand great pressures. This fish would also eat other fish and not have any light to see by.

Once the students have invented their fish, see if they can find an example of the fish using books and magazines. Have the students compare their fish to the fish they found to see what differences there are. Do not worry if the students can not find a fish to exactly fit their ideas. Remember, this activity is invention and creation.

The actual cards displaying the designs will be found in the pocket section.

Fish Behavior

Fish behavior is a series of mini activities which need not be done in any given order.

Materials:

Fish tank (5-10 gallons), gold fish, mummichog, stickleback or any other small bony fish with a swim bladder, two small cages made of plastic which would allow water to freely circulate but not allow fish to escape, lead shots, toy boat motor with propellor, hand nets, hip boots, small aerator pump, and sea water.

A. The idea of this investigation is to see the changes of fish's bouyancy through time. If one fish is kept in the upper surface waters of the aquarium and another is subjected to the bottom — changes of bouyancy should be noted. The bottom fish will have positive bouyancy and the surface fish will be slightly negative when first let out of their cages. This activity may be productive as a student project.

1. Have them modify the small cages so that they will allow some movement of the fish, yet confine them within a few inches in depth.
2. Secure one cage near the surface and put in another lead shot to hold the second cage on bottom.
3. Leave these overnight and allow the fish to escape in the morning, while observing their activity.
4. Have them discuss what is meant by positive and negative bouyancy.

B. The next part of the activity is rheotaxis or fish alignment with currents. Use a small toy boat motor with propeller. Place this in a 10 gallon aquarium with small fish as sticklebacks, mummichogs, or other fresh water species. Turn the motor on and observe the fish alignment and swimming behavior. The fish will orient themselves with the current and use their adapted fins to swim against it. This activity enables one to study which fins are best adapted for swimming behavior.

1. Discuss what the students think would be the reaction of other fish species when placed under the same conditions.

C. Fish also behave differently with respect to mating behavior. The Lumpfish *(Cyclopterus lumpus)* and the 3 spine stickleback *(Gasterosteus aculeatus)* exhibit similar territorial behaviors especially during their mating season. The male lumpfish develops a flaming-red abdomen during mating season, compared to the slate-grey female. After spawning, the male kicks the female out of the nesting site and guards, as well as aerates, the eggs by sweeping them with his fins. Any intruders, including divers, are greeted with an aggressive bump from this strange looking fish. During this whole behavior the lumpfish fasts until the eggs hatch. The male stickleback manifests similar behavior and is well documented in psychology readings. See ***Fishes of the Gulf of Maine*** (see bibliography for additional information).

1. Have students find examples of other territorial behavior as in sharks, small mouth bass, wolfish, etc.

2. Have the students set up sticklebacks in a fresh water or salt water aquarium.

   Even during non-mating seasons, the fish will set up territories in-the-water-column. They perform this by holding their tails at right angles to one another. Set up two separate tanks and let the fish establish territories. Introduce a fish from the opposite tank. Try placing a stickleback in a small jar with aquarium water (small airpocket for oxygen). Place the jar with the fish in the other tank.

   1. What is the response from the other fish?
   2. Discuss the senses of fish and the observed phenomenon.

D. A final part of fish behavior is adaptation to changing salinities. Have the students perform this activity with sticklebacks which may be obtained from local clam flats where there is prominent amounts of eelgrass (*Zostera*). Small hand nets or seins will enable students to collect these forms at mid-tide in the fall and spring of the year. Snug fitting hipboots are also needed for walking on the mudflats.

   After collecting these fish, place them in some salt water aquaria. Aerate the water with a small pump. These fish are extremely hardy and will withstand gradual changes of temperature. Have the students dilute the sea water by 90%, 75%, 50%, 25% and finally have a separate container of fresh water. Try placing a few sticklebacks through these solutions over a period of a week (allow at least one day's time for each solution). At the end of the investigation have students hypothesize how the fish are able to do this.

Odd Fish

Many fish that inhabit our oceans have interesting peculiarities such as unusual skin structures, fleshy appendages, luminescent lanterns over their bodies, strange walking legs (modified pelvic fins), etc. Have students bring in pictures and describe these strange modifications. Perhaps actual specimens may be available from a local zoological exhibit such as the one at the University of Maine. Use what sources you have available, such as encyclopedias, picturebooks, and magazines.

Have each student research a survival factor. Examples include: distruptive coloration, camouflage, mimicry, school behavior, countershading, speed, hiding ability, spines, teeth, size of body, aggressive behavior, etc. A mural of examples of survival factors could also be developed.

Migrating Fish

There are certain fish that move regularly between salt and fresh water. With this mobility, these fish must overcome certain chemical barriers. Living in the watery environment, a fish must keep an equilibrium of the salts in its blood and body fluids and those which may or may not be in the surrounding environment. A salt water fish has less salt content in its body fluids than the surrounding sea water. A fish's body uses water to dilute the higher salt concentration on the outside. Thus, the marine fish must contend with the loss of water from its body tissues and blood. It must constantly gulp water to keep from shrinking up. The freshwater fish has the opposite problem. Water constantly moves into the body so the fish must excrete the excess water.

Freshwater fish may be divided into two groups: 1) those that spend their entire lives in fresh water and 2) those that spend part of their lives in the sea. Those fish that feed and grow in fresh water, but return to the sea to breed, are called catadromous. These include the Common Eel (*Anguilla rostrata*), the stickleback *(G. aculeatus)* and others. Those fish that feed and grow in the sea and ascend the rivers at regular intervals to spawn are termed anadromous. Such examples are the Sturgeon (*Acipenser*), which spends time in the Kennebec River, the Atlantic Salmon (*Salmo*), Shad (*Alosa*), and others.

Many fish undergo a metamorphosis (change of form) from the young larval stages to the adult. This is not unlike insects or crustaceans such as lobsters and crabs. Such fish examples of metamorphosis include the flatfish (winter flounder, plaice, halibut, etc.), the giant oceangoing sunfish (*Mola mola*) which is often seen on the surface waters along the Gulf of Maine, and the semi-tropical fish called the lookdown. There are many examples of changing body forms with fish. Have your students research them and report these to the rest of the class.

Food Webs

Obtain the film, *Life in the Sea*, from the UMO film library and show it to your students. Tell the students to watch carefully for relationships they can find about the food habits of different organisms. Discuss the pyramid structure of food webs with producers at the bottom making food from sunlight and nutrients. Notice how there are more producers at the bottom which is necessary since energy is lost by the transference involved by consumers eating the lower level organisms. The relationship is generally 10 grams of producer necessary for each gram of the consumer. Each level you go up requires 10 times the lower level weight to become 1 gram body weight of that consumer level. Use examples from the film.

You might have the students discuss the following:

1. Give some examples of primary producers.
2. Detritus is decaying organic matter on the sea bottom. What organisms would consume detritus?

3. Consumers are organisms that eat other organisms. Name some consumers.

4. Try to start with a primary producer and go up the food chain naming the primary consumer and any secondary or tertiary consumers the students can think of.

Fish in the Lab

Aging Fish

Given adequate food and space, fish will continually grow. In this case the oldest fish would be the largest, but in nature conditions are less than ideal. Generalizations do not always hold true. It is safe to say, though, that most fish in the natural environment rarely stop their growth or die of senility.

If recently hatched fish are examined from the same brood (hatched at the same time from the parent) their size would be the same. These newly hatched larvae begin to feed on planktonic organisms in the surrounding water column; however fish such as the trout may live off their yolk until it is completely absorbed. Conditions of food, space and other requirements may be equal upon hatching, but some of these fish are more hardy and grow faster than others. As time passes, the fish may become separated. Currents may carry some of the larval forms to areas where there is less food. Such factors may account for variation in length and growth rate among members of the same brood.

There are a number of methods to calculate the age of members of fish populations. They are: scale counts, otolith counts, and vertebrae counts. Each has its limitations and advantages. The advantages are being able to judge the number of years of growth by observing scales (like that of studying annual rings in trees), otoliths (earstones) and even such structures as the vertebrae. The otoliths and vertebrae are usually a secondary means of determining age. They require dissection and sometimes elaborate techniques to prepare them. As a result, scales are used more often.

Scales grow as the fish grows. As they grow, annual layers are deposited in hard parts of the fish. This is especially recognizable in fish of the temperate and boreal zones (above Cape Cod to the Arctic waters). New growth is laid down by the layer of skin which covers the scales on the outside, forming all around the edges. The scale and other hard parts of the fish grow faster during the heavy feeding months of the summer and slow down during bad feeding seasons, usually winter. When the growth subsides, the rings are closer together and appear darker, when observed under low microscopic magnification (20-40X). Each of these darker rings is an annulus and usually demark one year's growth. The age of the fish can be roughly determined by counting the rings starting with the clear area of the center called the focus. The focus represents the original scale of the young fish. It appears on most fish when they are one-half inch to one inch long and do not increase in number, but grow as the fish grows. A typical fish that exemplifies good growth patterns on its scales is the haddock (*Melanogrammus aeglefinus*).

Lab Investigation: Determining the Age of Fish Through Observation of Scales.

With increasing demands on fish stocks around the world it has become very important to know the age composition of each type of fish. Such knowledge about the amount of growth gained each year and the life span of fish, enables man to harvest the fish crops more efficiently.

One method of determining age is the length-frequency distribution. This is performed on large numbers of fish and is based on the theory that all fish of one size are approximately the same age. The limitation of this method is that: 1) it does not separate older age groups which tend to remain the same size; 2) variable environmental conditions may favor one age group over another; 3) hatching does not occur at the same time each year; 4) the method requires a large number of randomly selected fish.

Another means of determining age is by marking the fish. This is a positive means to identify released and recaptured fish of a known age, but offers a number of disadvantages as: 1) cost of method; 2) time involvement; 3) damage to the specimens; and 4) the small amount recaptured.

The last method of determining age is through examination of the annual layers deposited in the hard parts of a fish of either the scales, otoliths or spine. The limitations of this method is that accuracy depends on the interpretive ability of the examiner and the distinctiveness of the annual layers.

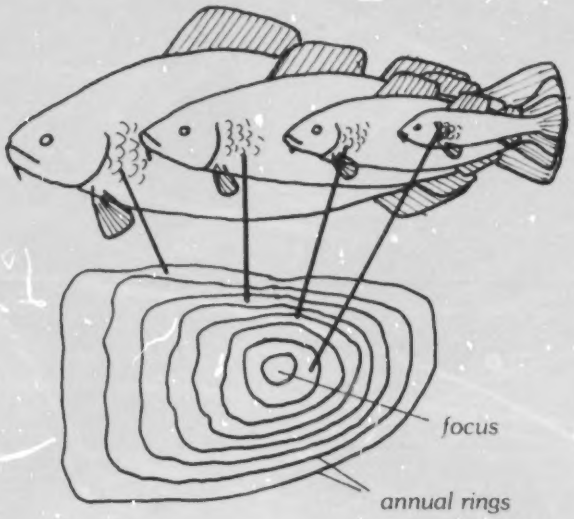
Methods

Select fish with large scales. These include such fish as herring, alewife, bass, perch, haddock, cunner, salmon, anchovy, silversides, etc. Other swift-swimming fish such as the mackerel and tuna have reduced scales to enhance streamlining. The scales of common eels (*Anguilla*) are microscopic or not present. You may obtain some of the above fish from a local fish market or directly from a seafood processing plant or local fisherman. Fully-formed scales from each specimen should be selected. When a scale is lost, the regenerated scale does not form the old rings. Also, a false annual ring is produced by females just prior to spawning as reabsorption occurs.

After scales are selected they may be stored for later use by placing them in an envelope or by pressing them between pieces of paper. The scales

have their own cement called mucus. The paper that the scale is on should be labeled with the following information: type of species, weight, length, place, sex, time and method of capture and name of the collector. Another useful means of examining the scales is by placing them between two layers of thin clear plastic and mounting them in a 35 millimeter slide blank. The magnification of the scales is accomplished through projecting them with an ordinary 35 millimeter slide projector. This method facilitates storing and cataloging and can be done by the whole class at once. Scales may also be examined under the stereoscope at 20-40X. Detailed examinations of parts of the scales may also be of interest. A compound microscope with 50-100X objectives would be of some use especially for smaller scales if large ones are not available.

Fish Growth and Scale Size Relationship



Scales from a large number of different species of fish would serve to show the variety of size and the difficulty of analysis of age. Start out with some of the easier specimens first, such as herring or haddock. A comparison of bonyfish scales to the scales of sharks would also be of some interest. The scales are more primitive in type in these animals. These are called placoid sales. Other types of scales include those of the Gar and the Atlantic Sturgeon. They are termed ganoid scales. Example diagrams of scales will be found in the pocket.

Age and Growth

In order to determine the age of fish by studying the scale structure, several terms should be explained:

Annulus — the annual mark or zone on fish scales which is formed once a year.

Focus — the small, clear area near the center of the scale which represents the original scale of the young fish.

Ctenoid Scale — the scale of a bonyfish (teleost) which possesses small sharp spines (ctenii).

Cycloid Scale — the scale of a bonyfish without spines (ctenii).

There are variations of these scales. The spines of ctenii and the position of focus varies with each species of fish.

The *annulus* is recognized in one of the following ways: 1) "crossing over" where the onset of fall or winter causes several ridges or circuli to flare outward and end on the side of the scale, rather than circle the focus; 2) "discontinuous circuli" where the individual circuli do not grow together in a complete line because the scale stops growing and 3) extreme crowding of the circuli which occurs, first, prior to resumption of growth.

Purpose:

To determine the age of a bonyfish by examination of its scales.

Materials:

Hand lens or dissecting microscope, compound microscope slides, various species of fish or scales provided by teacher metric ruler, projector — microprojector or slide projector, and plastic sheeting and empty slide (if demonstrations are desired).

Procedure:

Remove a scale from several areas of each specimen and determine if it is cycloid or ctenoid. If the scale is ctenoid, remove further scales around the area of the pectoral fin. Cycloid scales should be taken from an area between the dorsal fin and the lateral line. Remove 3 scales from the indicated area from each specimen. Make a wet mount of the scales or place them between two glass slides for microscopic observation. Use both a compound microscope and a stereoscope. Record all observations.

Data Recording

Make illustrations of the general features of the scale noting: *annuli, focus, circuli, ctenii* (when present). Determine the distance between *annuli* on the scale by the use of a metric ruler. To determine the age, each scale should be counted twice, at different times to arrive at an accurate interpretation. Count one year of growth for each annulus.

Limitations and Sources of Error:

This could result in incorrect reading of scales. Some fish show no definite *annuli*. Other errors might result in the use of imperfect scale or scales that have been rejuvenated. Errors in age

determination increase with the age of the fish and errors made in determining the location of the first *annulus*.

Shark Dissection

The dogfish (*Squalus*) is a good example to study in the lab. Diagrams are found in the pocket.

External Anatomy:

Fresh or preserved specimens should be used to study the shark. Refer to the shark dissection diagram for the features as you complete these exercises.

A. Body Structure

1. Study the jaw structure and teeth of the specimen. What type of diet do you think the dogfish has? The size and shape of teeth vary significantly among sharks. Compare the tooth structure of the dogfish to those of people. Unlike man who has permanent teeth, shark's teeth are continually replaced. They are not anchored in the jaw bone but grown in its skin. They move steadily forward as they increase in size. How do the shape of the dogfish compare to the dentacles (placoid scales) covering the outer skin of the body? (If a specimen is available, remove a small piece of skin and view it under the microscope.)

2. You might have the students discuss the following: Noting the spiracle on the shark, compare this with the gill opening of a fish. Count how many gill openings this shark has. Do all sharks have the same number of gill openings? Where does the spiracle lead, what function does it serve, and from what structure do you think the spiracle has evolved?

3. Have your students study the eyes of the shark. Have them notice that there are no lachrymal glands or ducts developed at the margins of the eye like in humans. Ask why this is not necessary? Sharks have a third eyelid known as the nictitating membrane at the front corner of the eye. Have your students locate this and inform them that this can be pulled down to cover the whole surface, and ask what use this serves? Make a list of other animals that have this structure. The general structure of the eye is not unlike our own. It contains the lens, iris, cornea, retina, etc. that are found in land forms. Have your students find some of these structures. Notice the cornea is somewhat flatter than our own. Scientists once believed that sharks were extremely nearsighted but further investigations have demonstrated the shark to have excellent eyesight.

4. The shark's sense of smell is also well developed. The shark's brain is small, but its smelling area, the olfactory bulbs, give the shark one of the most sensitive noses of all fish. It is well known that the smell of flesh or blood, or of a decaying carcass will attract sharks from great distances. When both nostrils of a dogfish are plugged, the shark loses its power to find food. When one nostril is blocked, the animal keeps turning toward the side that is getting the strongest scent. The fish tracks its food by comparison between the responses of the two sacs. Study the nostrils of both the shark and the skate. Where are they located? Do the placement of these suggest anything about their feeding behavior? Do the nostrils lead to the inside of the mouth cavity?

5. Note the two dorsal fins of the dogfish. The upturned (heterocercal) caudal fin and the two sets of paired fins. The front pair (anterior) are called pectoral fins and the back (posterior) are termed pelvic fins. The two dorsal fins are preceded by spines. These sometimes inflict a painful puncture wound for those fishermen that handle these fish carelessly. Have your students suggest some relationships between the presence of well developed fins and the existence of paired-biting jaws.

6. Sharks have a third sense which they usually use first in homing-in on their prey. The system is called the lateral line which extends along the sides of the body and divides into several branches over the head. The system is like inborn radar. Sensory cells located in this intricate canal beneath the skin are sensitive to water movements and underwater sounds — especially those of low frequency. Note the abundant pores around the head and beneath the snout. These are called *ampullae of lorenzi*. Squeezing these pores results in the exuding of a jelly-like material. Cutting a small section of skin around one of these pores and examining the underneath surface reveals an expanded *ampulla*. Can your students suggest why the lateral-line sensory structures are concentrated around the head? Why might the lateral-line system be more effective than ears for sensory detection?

7. Sharks and their kin have internal fertilization. Ask your students how this compares with most other fish. Males have claspers located by their pelvic fins. These aid in copulation. How is the sperm transferred to the female?

Internal Anatomy:

View a dissected specimen or open the coelomic cavity on an unprepared specimen. Examine the internal organs and compare the structures to the diagrams.

B. Internal Organs

1. Examine the large liver lobes. During World War II sharks' liver was used as a source of vitamin A and thousands of sharks were netted

daily. Can you suggest why the liver is so much larger than the rest of the body organs? (This is thought to be a food storage organ.)

2. The short digestive canal terminates at the anus. Cut open the stomach and examine the contents. Many larger sharks such as the Blue or White shark have been found to contain such things as rolls of tarp paper, bottles, sneakers, wrenches, etc. within the stomach. Can your students suggest why a shark would eat such objects.

   Have your students sketch the opened digestive tract and label each section with its function and how it is adapted for that function. Have them find the spiral valve in the small intestine and ask why this design is advantageous. Compare it to a human intestine.

3. Discuss how the ovaries of the female dogfish shark differ from the testes of the male. Examine the uterus for embryos. Ask if the embryos are surrounded by an egg case. Most sharks are viviparous (young born alive) compared to ovoviviparous (egg laying) as in the skate. Compare egg laying development and survival with live bearing, and how might internal development of the young be of survival advantage to most species of shark.

4. Extend an incision between the gills to the lower jaw. Observe the cartilaginous rods which support each gill arch. Do such structures indicate the probable origin of the lower jaw?

5. Have your students examine the heart and heart cavity. Cut into the heart and observe the two cavities, the *atrium* which receives blood and the muscular walled ventricle which pumps the blood. Blood is pumped from the ventricle via the aorta to the gills. From the gills, oxygenated blood is delivered to the rest of the body. Have your students diagram the circulatory system of the shark from the point where blood enters the heart until it leaves the gills. Have them indicate this by using arrows to show the direction of flow.

C. Skeleton, Eye Formation

1. If you have time, have your students examine the cartilagenous skeleton and skull. Noting the size of the olfactory lobes in relation to the rest of the brain, have them expose the brain and semicircular canals which are used for equilibrium and balance. Tell the class that the olfactory lobes are used to interpret smell. Have them find the olfactory nerve from the lobe to the nostril, and ask if the sense of smell is well developed in shark.

2. Examine the internal areas of the eye for the various parts such as: lens, iris, pupil, ciliary muscle, retina and various eye muscles. Ask your class how this compares to the human. Also point out the optic nerve attached to the back.

Bony Fish Dissection

External Anatomy:

It would be good for your class to select several different specimens (whatever fish you have locally, such as perch and sunfish) and compare their external features. The fish may be fresh or marine as both have the same anatomical features. The internal anatomy is in the pocket, as well as the general external anatomy of a composite fish.

Commonly, a fish's body is torpedo-shaped (fusiform) and slightly ovoid in cross-section. There are many interesting departures from this idealized case. These range from globe shapes (puffers — globiform) through serpentine (American eels — anguilliform) to thread-like forms (snipes). How can you tell that a flatfish like a flounder is laterally compressed (flattened from the sides) rather than dorso-ventrally compressed (flattened from the top as observed in the skate).

There are many interesting forms of fish but basically all are formed on a common plan called bilateral symmetry. This means the body has distinct left and right halves that are nearly mirror images of one another. There is strong cephalization (forming a head) and a compactness and streamlining of the body right to the end of the tail. The tail is considered a complete part of the body. It is not an appendage, as the fin is.

A. Body Covering

1. Many fish have thick skins which are continuous with the lining of all the body openings. Mucous cells provide a coating which is both protective and effective in streamlining the fish for swimming. Does your specimen have a very tough skin? Does it feel slimy?

2. Scales are usually imbedded in the skin, too. They may be small as in the mackerel or very large as in the herring. The herring also has loosely-attached scales (deciduous) as compared to those firmly-attached as in the flounder. The types of scales (ganoid, cycloid, or ctenoid) serve as characteristics of major bony fish groups. The types of scales and the number of scale rows along or around the body aid in identification.

3. Use the activity on age determination and scale type. What type of scales do your specimens have?

B. Appendages

1. The appendages of fish include the various fins and the *cirrhi* (fleshy projections as on the Sea

Raven). Fins are categorized as median or paired.

2. The dorsal fins show much variation. They may be continuous, or divided partially or completely into separate parts. The dorsal fin may also consist of either spines (soft or hard) or rays or both. Spines appear to be transparent, hard and sharp at the ends. Rays are soft and appear segmented when held to the light or under low power under the stereoscope. The rays may also branch out at the end. Spines may further be found associated with other structures such as the opercular spines of the Sea Raven. What type of dorsal fins do your specimens have? Some dorsal fins fold down, as in the mackerel. This is to aid the streamlining of a fish built for fast swimming. Make a sketch of two different types of dorsal fins. What advantage is there to having spines or soft rays?

3. Other median fins include the tail (caudal fin) and the anal fin (just behind the vent on the lower side). The trout or salmon-like forms have a fatty adipose fin. Fins also may be reduced to a few disconnected spines as in the stickleback. If sticklebacks are alive and available in the aquarium, net one and try to pick it up. How do the spines respond?

4. Pectoral fins may vary also. They may be enlarged as in the sculpin, sea raven or flying fish, or more regular in shape, as in the trout and flounder.

5. Pelvic fins vary in shape and position. Their support comes internally from the pelvic girdle. Most soft-rayed fish have pelvics located abdominally, as in salmon forms. They may be located below the pectorals (see figure of generalized fish) or they may be under the throat (jugular), as in the blennies, which use these as support as they rest on the bottom. Some pelvics are modified, as in the shark and skate, to form claspers used in reproduction. The lumpsucker has modified pelvics which form a holdfast organ that looks like a suction cup on the belly. Observe these on an available specimen. Where are the pelvics on your fish? What function do you suppose they form?

6. Observe the caudal fins of several demonstration specimens. Is there a relation between the type of tail fin and habit of fish (for example: the tail of a mackerel is forked and thin)? Compare a mackerel tail fin and that of a cunner, mummichog, or perch. Select at least three types of tail fins and draw them.

7. On some fish such as the mackerel, there are finlets near the tail or a lateral keel (found also in sharks), as in the tuna. What do you think the function of the lateral keel is?

As a follow up to the study of fin patterns, observe some sticklebacks in a 10 gallon aquarium. Study the 3 spined stickleback (*Gasterosteus aculeatus*) which is well described in the *Fishes of the Gulf of Maine*. The kind of life carried on by a fish is expressed not only in the form and flextures of its body, but also in the patterns and motions of its fins. For example, watch the nest building stickleback. Pectoral fins are used in braking motion as its other fins are unsuited for grasping. Therefore, the fish must use its jaws to build the nest. This activity requires a long and varied series of regulated movements of the body. What allows this precise motion is the lively and adaptable motions of an array of flexible fins.

A second activity that could be done is to study the variation in body form among fish and find fish in the lab that would fit each category. Compare their fin structure and body form and make a hypothesis of their behavior and habits. A check with the checklist will be helpful. (Hint: To aid identification of form, make silhouettes with the use of an overhead projector or slide projector as a light source.)

Internal Anatomy:

Take a modern representative of a bony fish, such as a perch, cunner, sea bass, rock bass, etc. and carefully cut the left side-belly area to expose the internal organs of the fish. The picture will help in identification of structures.

A. Gill Structure

1. Take the gill cover (operculum) off the left side of the fish and observe the gills. If the specimen is fresh, note the red color produced by blood capillaries. Sketch the gill structure. If possible, study the gill structures of a herring. Hypothesize its eating habits. How does the fish obtain its food?

B. Internal Organs

1. Identify the major internal organs. Make a diagram showing the route of the blood from the heart (two chambered) to the gills.

2. What is the color of the lining of the digestive cavity? This lining is called the *peritoneum*. If it is white, the fish is generally a carnivore. Black indicates a herbivore.

3. Observe the swim bladder which is found under the vertebral column and kidneys. Note that it connects to the esophagus. This flotation device is unique among the bony fish and very important for maintaining bouyancy. How does this compare to a shark?

   Depending upon the fish, the swim bladder may be used to breathe air.

4. Study the digestive tract. Make an incision through the small intestines and a small cross-section. How does the internal surface area

compare to that of a shark's intestine? (Note the spiral valve in the shark.)

5. Count the number of body openings for expelling body wastes. How does this compare to the shark?

Keying Out Fish

A fish key is a series of questions or statements that may be asked about the characteristics of a fish. If you do not know the scientific name (genus and species) of a fish, you observe the fish and answer the questions in the key to find the scientific name. At the end of each question that pertains to your particular fish is a number directing you to the next question. When you have answered enough questions, you eventually find, not a number, but the scientific name of your fish. Choose a fish and carefully answer each question proceeding through the key. If a question is answered incorrectly you will not obtain the correct scientific name.

The hammerhead shark is taken through the key as an example of "Keying out a fish." A key is provided in the pocket and the key may be copied and handed out to your class.

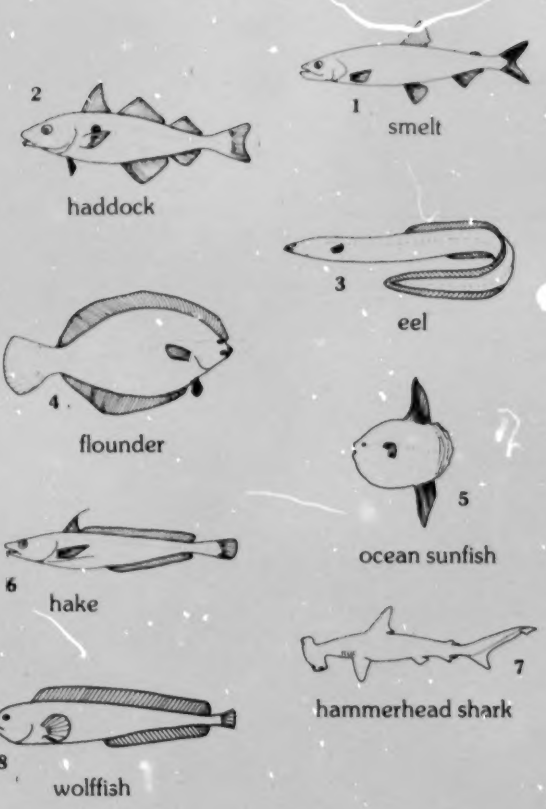
Answer Guide

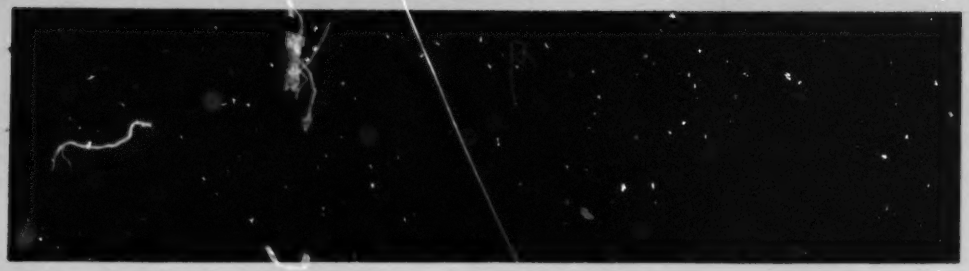
Fish Key

Sample key for Hammerhead Shark

1. a. Does the fish have a body like a snake? **2** *(no)*
   b. Does the fish not have a body like a snake? **3** *(yes)*
2. a. Does the fish have a beaklike mouth? **American Eel**
   b. Does the fish not have a beaklike mouth? **Lampreys and Hagfish**
3. a. Does the fish have eyes on the same side and a flattened body? **4** *(no)*
   b. Does the fish not have eyes on the same side and no flattened body? **5** *(yes)*
4. a. Does the fish have a forked tail? **Halibut**
   b. Does the fish not have a forked tail? **Flounder**
5. a. Does the fish have placoid scales? **6** *(yes)*
   b. Does the fish have scales other than placoid? **7** *(no)*
6. a. Does the fish have a pointed head? **Dogfish shark** *(no)*
   b. Does the fish not have a pointed head? **Hammerhead Shark** *(yes)*
7. a. Is the fish body full moon shaped with a little caudal fin? **Ocean sunfish**
   b. Is the fish body not distinctly moon shaped and has a highly visible larger caudal fin? **8**
8. a. Is the fish club shaped like a baseball bat? **Wolffish**
   b. Is the fish body not club shaped like a baseball bat? **9**
9. a. Is there evidence of a chin barbel? **10**
   b. Does the fish have no chin barbels? **13**
10. a. Is the caudal fin not notched or only slightly (just barely) notched? **11**
    b. Is the tail decidedly notched? **12**
11. a. Does the fish have three distinct dorsal fins (top side)? **Cod**
    b. Does the fish have two distinct dorsal fins? **Hake**
12. a. Does the lower jaw extend beyond the upper jaw? **American pollock**
    b. Does the lower jaw not extend beyond the upper jaw? **Haddock**
13. a. Does the fish have finlets (small fin like growth between tail and dorsal and anal fin)? **14**
    b. Does the fish not have finlets? **15**
14. a. Are the dorsal fins distinctly separated? **Mackerel**
    b. Are the dorsal fins not separated distinctly? **Tuna**
15. a. Does the fish have a small adipose fin (small fleshy fin between the caudal and dorsal fin)? **Smelt**
    b. Does the fish not have a small adipose fin? **Alewife**

Fishes on the key





Fish Recipes

Fish Pie

serves 4 to 6

1 kg. (2 lbs.) boneless fish (cod, pollock, haddock)
1 small box Ritz crackers (crushed)
.25-.5 kg. (½ to 1 lb.) margarine (or butter if preferred)
3 ml. (½ tsp.) of Worchestershire sauce
3 ml. (½ tsp.) of brown sugar

1. Melt ½ margarine
2. Pour over crumbs and mix well with Worchestershire sauce and ¼ of the crumb mixture on the bottom of the pan.
3. Put ½ the fish on top of the crumbs, add a layer of crumbs, add the rest of the fish and top off with the rest of the crumbs.
4. Bake for ½ hr. at 400° F (205° C)

Dieter's Delight

serves 6

1 kg. (2 pounds) haddock fillets
30 ml. (2 T.) melted fat or oil
30 ml. (2 T.) lemon juice
5 ml. (1 t.) salt
3 ml. (½ t.) paprika
Dash pepper

1. Cut fish into 6 portions.
2. Place fish in a single layer, skin side down, on a well-greased baking pan.
3. Combine remaining ingredients and mix well.
4. Pour sauce over fish.
5. Broil about 10 cm. from source of heat for 10 to 15 minutes or until fish flakes easily when tested with a fork.
6. Baste once during broiling with sauce in pan.

Eels Roasted en Casserole

Salt and pepper
90 ml. (6 Tbls.) Olive oil
1 lemon, extra
1 kg. (2 Lbs.) prepared eels
Juice of 1 lemon
15 ml. (1 Tbls.) chopped parsley

Once the eels are prepared in 10 cm. chunks, make a seasoned olive oil of blended parsley, lemon juice, and olive oil. The eel is dipped and salt and peppered for one hour. Next the eel is placed in a preheated broiler (350° F) 175° C at 10 cm. below the flame in a baking dish. After 10 minutes of broiling, baste with the olive oil and blend. Broil another 5 to 10 minutes till done and serve hot with wedges of lemon. This serves 4-6.

Smoked Hake Steamed

1 kg. (¼ lb.) butter, melted
30 ml. (2 Tbls.) chopped fresh mints
1 kg. (2 lbs.) Smoked Hake Fillets

Arrange the fillets in a steamer. Steam over boiling water for 12 minutes until done. Next place the fish on a platter you preheated and pour over melted butter. A garnish of chopped mint and you are ready to serve 6 people.

Shark N' Chips

Cut a prepared shark into 1 cm. chunks. After preparing a batter of 3 ml. baking powder, 1 ml. pepper, 1 ml. salt, 250 ml. flour, 175 ml. water, and 2 beaten eggs, dip the shark chunks. Deep fry turning once at 375°F (190°C). When golden brown, serve with french fries or potato chips.

Other Unit Materials You May Wish To Use

Northern New England Marine Education Project Infusion Units

A. Have You Been To The Shore Before?
This unit has an excellent section on establishing a saltwater aquarium. The saltwater aquarium would be a necessity for keeping your own live marine fish. A valuable aid for integrating fish with the marine environment.

B. What Adventures Can You Have In Wetlands, Lakes, Ponds, and Puddles?
This unit would be excellent for integrating freshwater fish with marine fish encompassing all the fish of our state. A section on creating an aesthetic classroom environment is an excellent activity with subsections on fish printing, yarn fish, and clay fish plaques which are directly relevant.

C. What Is Our Maritime Heritage?
This unit can integrate the fishing industry with finfish. The section on fishing vessels under sail provides historical data with the section on commercial vessels today giving an overview of current practices and boats.

D. Is Our Food Future In The Sea?
This unit has a section on finfish farming and is excellent for integrating finfish into the overall picture of food from the sea.

E. Marine Education Materials Service at the Virginia Institute of Marine Science
Gloucester Point, Virginia 23062
This is another source of useful marine education materials. If you are interested in a specific topic you may call for a computer search which will provide you with the appropriate materials available in MEMS. You may then view the microfiche materials on the MEMS microfiche viewer at the UMO Marine Science Education Department in Shibles Hall, or for a nominal fee have the microfiche duplicated for your use.

MEMS Topics:
Included here are a few of the MEMS microfiche topics available.

When ordering MEMS microfiche include the MEMS number.
MEMS# 000106 1977 Schuman, S. ***Make Your Own Fish Trophy.***
This article is a good reference for several trophy making techniques.

MEMS# 001068 1979 by AFTM Sport Fishing Educational Foundation. ***Leaders Guide For Organizing Sport Fishing Group Activities — Youth Fishing.***
An excellent reference and guide for encouraging fishing activity.

MEMS# 001070 1979 by AFTM Sport Fishing Educational Foundation. ***Fishing Fundamentals for Beginning Anglers — Student's Edition.***
An excellent reference for fishing basics.

MEMS# 001047 1973 by unknown author ***First Aid for Fishermen.***
This resource is excellent for information concerning what to do when the occasional accident occurs.

F. Anderson, Gary, and Bromer, Ann.
Salar: The Story of the Atlantic Salmon
100 Park Avenue
New York, NY 10017
A source for integrating salmon into the curriculum. This unit is complete in presenting the many aspects of this fish. History, fishing, and the life of the salmon are among the topics given.

National Agencies

United States Department of the Interior
Fish and Wildlife Service
One Gateway Center
Newton Corner, Massachusetts 02158
This organization can be an invaluable resource. They offer a wide variety of published information on the Nation's fish and wildlife resources.

National Marine Fisheries Service
Post Office Box 1188
Gloucester, Massachusetts 01930
This organization is a branch of the National Oceanic and Atmospheric Administration. They conduct various programs of management, research and services related to marine resources.

Regional Fishery Management Councils
New England Council — Suntaug Office Park
5 Broadway, Route 1
Saugus, Massachusetts 01906

State Agencies

New Hampshire Department of Fish and Game
Education Division
Bridge Street
Concord, New Hampshire 03301
Telephone: (603) 271-3421
The department can provide printed material for teachers. Write or call for details.

University of New Hampshire
Maine Advisory Service
Marine Program Building
Durham, New Hampshire 03824
Telephone: (603) 862-1889
Extensive special services include outreach programs in the schools, a speaker's bureau, and marine resource workshops.

State of Maine Department of Inland Fisheries and Wildlife
284 State Street
Augusta, Maine 04333
Telephone: (207) 289-2871
The department can provide a variety of materials prepared for the general public and also appropriate for your students' level. The department's magazine, Maine Fish and Wildlife, is very highly recommended.

State of Maine Department of Marine Resources
State House Station 21
Augusta, Maine 04333
Telephone: (207) 289-2291
The DMR provides many valuable services to classroom teachers, including numerous publications, study projects by students, and assistance in setting up programs and planning curriculum.

University of Maine Sea Grant Marine Advisory Program
Sea Grant Office
Coburn Hall
Orono, Maine 04469
Telephone: (207) 581-2666
Sea Grant has many research and commercial fishing publications available. One resource we highly recommend for your age group is ***Marine Fisheries of Maine***, a series of six color illustrations with cassette tapes.

Fisherman's Library
Department of Marine Resources/Bigelow Laboratory for Ocean Sciences
McKown Point
West Boothbay Harbor, Maine 04575
Telephone: (207) 633-2173
This institution can offer teachers material to assist them in preparing to teach many marine related subjects.

Maine Fisherman's Cooperative Association
Post Office Box 4812 D.J.S.
Portland, Maine 04112

Commercial Fisheries News
Post Office Box 37
Stonington, Maine 04681
Telephone: (207) 367-5590
Robin Peters, General Manager
This is a newspaper dealing with the commercial fishing industry.

Maine Department of Marine Resources
Fisheries Research Laboratory
West Boothbay Harbor, Maine 04575
This is an excellent spot for a field trip.

Mr. & Mrs. Fish Education Program
Gulf of Maine Aquarium
Marine Educational Program
21 Vocational Drive
South Portland, Maine 04106
Deborah Hall and Jeffrey Sandler
Telephone: (207) 799-6234
The Fishes present a program dealing with many marine aspects. A reasonable fee (there are no pre-set fees) brings Mr. & Mrs. Fish to your school. Creative dramatics with a marine approach to learning are demonstrated.

Aquariums

Aquarium of the National Marine Fisheries Service
Woods Hole, Massachusetts 02543
Telephone: (617) 548-7684

New England Aquarium Corporation
Central Wharf, off Atlantic Avenue
Boston, Massachusetts 02110
Telephone: (617) 742-8830

The Gulf of Maine Aquarium
Commercial Street
Portland, Maine 04101
Telephone: (207) 772-2321

Field Sites

Fish Packing Plants in Maine and New Hampshire

Addison Packing Company
Southwest Harbor, Maine 04679

Bay Fish Company
Boothbay Harbor, Maine 04538

Paul F. Bayley
Pine Point Road
Scarborough, Maine 04074

Bayview Shellfish
Beals, Maine 04611

Belfast Canning Company
Addison Packing Company
Box E
Water Street
Belfast, Maine 04915

Booth Fisheries Division of Consolidated Foods Corporation
1 Booth Avenue
Portsmouth, New Hampshire 03801

Booth Fisheries Sub Consolidated Foods Corporation
Post Office Box 96
Lubec, Maine 04652

Borden Incorporated
Snow Food Products Division
Pine Point, Maine 04074

Bucks Harbor Seafood
Machiasport, Maine 04655

Central Wharf Fisheries Incorporated
27 Central Wharf
Portland, Maine 04111

Coastal Fisheries Incorporated
Post Office Box 643
Portland, Maine 04104

Coastal Fisheries Incorporated
Atlantic Avenue
Boothbay Harbor, Maine 04538

Global Seafoods Incorporated
7 Brentwood Road
Cape Elizabeth, Maine 04107

Holmes Packing Corporation
60 Ocean Street
Rockland, Maine 04841

Jay Fisheries Incorporated
East Sullivan, Maine 04632

Maine Fisheries Corporation
Holyoke Wharf
Portland, Maine 04104

McCurdy Fish Company
Lubec, Maine 04652

Mid-Central Fish Company
45 Custom House Wharf
Post Office Box 643
Portland, Maine 04111

Oceanview Fisheries Incorporated
Robinsons Wharf
Route 27
Southport, Maine 04569

Port Clyde Foods Incorporated
366 Route 1
Falmouth, Maine 04105

Port Clyde Foods Incorporated
Post Office Box K
Eastport, Maine 04631

Port Clyde Foods Incorporated
Stonington, Maine 04681

Portland Fish Company Incorporated
Custom House Wharf
Portland, Maine 04104

C.H. Rich Company Incorporated
Bass Harbor, Maine 04653

Royal River Packing Company
Yarmouth, Maine 04096

Saltwater Farm Incorporated
Varrell Lane
York Harbor, Maine 03911

Scandia Seafood Company Incorporated
102 Pleasant Street
Brunswick, Maine 04011

Scandia Seafood Company Incorporated
Bailey Island, Maine 04003

Scandia Seafood Company Incorporated
Georgetown, Maine 04530

Seafood Products Incorporated
Port Clyde, Maine 04855

Sebasco Wharf Incorporated
Sebasco Estates, Maine 04565

Sid's Incorporated
Jonesport, Maine 04649

Stinson Canning Company
Prospect Harbor, Maine 04669

Stinson Canning Company
Water Street
Belfast, Maine 04915

Stinson Canning Company
Prospect Harbor
Gouldsboro, Maine 04669

Stinson Canning Company
Main Street
Southwest Harbor, Maine 04679

Stinson Canning Company
Bowery Street
Bath, Maine 04530

Villanova Incorporated
30 Tilson Wharf
Rockland, Maine 04841

Willard Paggett Fish Company
15 Central Wharf
Portland, Maine 04111

B.H. Wilson Fisheries
Battery Street
Eastport, Maine 04631

Jasper Wyman and Son
Milbridge, Maine 04658

Bibliography

Scientific

Allyn, Rube. ***A Dictionary of Fishes.*** St. Petersburg, Florida: Great Outdoors Publishing Company, 1967.
A highly illustrated general look at some of the more common types of fish.

Bigelow, Henry B., and Schroder, William C. ***Fishes of The Gulf of Maine.*** Washington, DC: United States Government Printing Office, 1953, 577. This book may be ordered through the University of Maine, Orono Bookstore.
A good complete reference for marine fish of the Maine Gulf, even though the book is slightly dated.

Herald, Earl S. ***Fishes of North America***. New York: Doubleday & Company, Inc., 1972.
A brief, but informative glance at North American fish. A very readable volume that should be in the collection of anyone interested in studying fish.

Lee, David S. et al. ***Atlas of North American Freshwater Fishes.*** Raleigh, North Carolina: N.C. State Museum of Natural History, 1980.
A thorough, up-to-date account of North American freshwater fish. Extremely accurate details concerning characteristics and habitat.

Lindberg, G.U. ***Fishes of the World***. New York: John Wiley & Sons, 1974.
This text is fairly technical, yet would be a good reference source due to its abundance of data. Very complete and well-organized.

Maine Department of Sea and Shore Fisheries. ***Harvesters of the Sea: The Story of Maine's Commercial Fisheries***.
A concise book of the industry and its history.

Muus, Bent J. ***Collins Guide to the Sea Fishes of Britain and North-Western Europe.*** London: Collins, 1974.
A richly-illustrated handbook providing brief and understandable introductions to the structure, habits, distribution, and economic importance of the fish of the Northeast Atlantic Ocean.

Stubbs, Lorraine L. ***The Atlantic Herring Clupea Harengus***. Department of Marine Resources, Augusta, Maine, 1979.
A good educational unit for herring. It could be valuable for studying this fish.

Wheeler, Alwyne. ***Fishes of the World***. New York: MacMillan Publishing Co., Inc., 1975.
Superbly illustrated, non-technical work consisting of brief descriptions of the world's fish. Could be helpful as a general resource.

Home Economics

Maine Department of Marine Resources. ***Buyers Guide for Maine Seafoods.***
This book is available from D.M.R. and shows the economic importance of several key species of fish and the marine organisms.

New England Marine Advisory Service. ***The Seafood Sourcebook.*** A Sea Grant Program Summer, 1978.
For $1.00, single copies are available from the State's Sea Grant Office at the University of Maine, Orono, or NOAA Marine Advisory Service National Sea Grant Program, 3300 White Haven Street, N.W., Washington, DC 20235.

Planet Ocean. ***The Dogfish Cookbook.*** The International Oceanographic Foundation, 3979 Rickenbacker Courseway, Virginia Key, Miami, Florida 33149.
This book is humorous as well as good for tasty recipes.

The Virginia Polytechnic Institute and State University Sea Grant Programs. ***Seafood Products: An Instructional Guide for Home Economics Programs.***
This guide is available for viewing at the Resource Center at the Northern New England Marine Education Project at University of Maine at Orono, Science Department, Shibles Hall, or Sea Grant Extension Division, Virginia Polytechnic Institute and State University of Blacksburg, Virginia 24061.

Children's Literature

Carrick, Carol. ***Sand Tiger Shark***. New York: The Seabury Press, 1977.
This book provides a superb account of the life cycle of the Sand Tiger Shark.

Darby, Gene. ***What Is A Fish?*** Chicago: Benefic Press, 1958.
The 48 page book is excellent for young students and helps them understand what a fish is. Available from University of Maine at Orono Learning Center, University of Maine at Orono Library, Orono, Maine.

Fife, Dale. ***Fish in the Castle.*** New York: Coward-McCann, Inc., 1965.
This book would be useful for a literature web. It tells the story of a boy and the grunion run.

O'Neill, Mary. ***The White Palace***. New York: Thomas Y. Crowell Company, 1966.
This book would be good for a literature web. The story concerns the life of salmon.

Annotated Filmography

Fish and Their Characteristics
This film is good for basic anatomy and differentiating a fish from other organisms. One drawback, easily corrected, is to tell the students that "cold blooded" is properly referred to as exothermic. Available from University of Maine at Orono. Film Rental Library, Shibles Hall, University of Maine at Orono, Orono, Maine 04469. Telephone: (207) 581-7541.

Life in the Sea
A film extremely useful for showing the interrelationships of fish and their environment in the multitude of food chains. May be available from University of Maine at Orono, ISC, Film Rental Library, Shibles Hall, University of Maine at Orono, Orono, Maine 04469. Telephone: (207) 581-7541.

Fishes of the Gulf
This slide show is excellent for showing fish from the Gulf of Maine. Available from D.M.R. State House, Station 21, Augusta, Maine. Contact Lorraine Stubbs.

Fence in the Water
A 44 minute film about Maine weir fishing. A good multidisciplinary film about fishing off the coast of Maine. Contact Peg Dice, Bodacious Films, 2022 Dat Street, Ann Arbor, Michigan 48104. The rental fee is $48.

Marine Fisheries of Maine
Filmstrip. A good filmstrip series relevent to fish, with gill netting, seining, trawling, and some weir fishing techniques displayed. Available from NNEMEP, Orono, Maine, University of Maine at Orono, Shibles Hall or University of Maine at Orono Library Learning Center. The filmstrip may be purchased from Sea Grant Marine Advisory Program, 30 Coburn Hall, University of Maine at Orono, Orono, Maine 04469. Telephone: (207) 581-2719. The cost is $48. which will be billed to you. Send no money initially.

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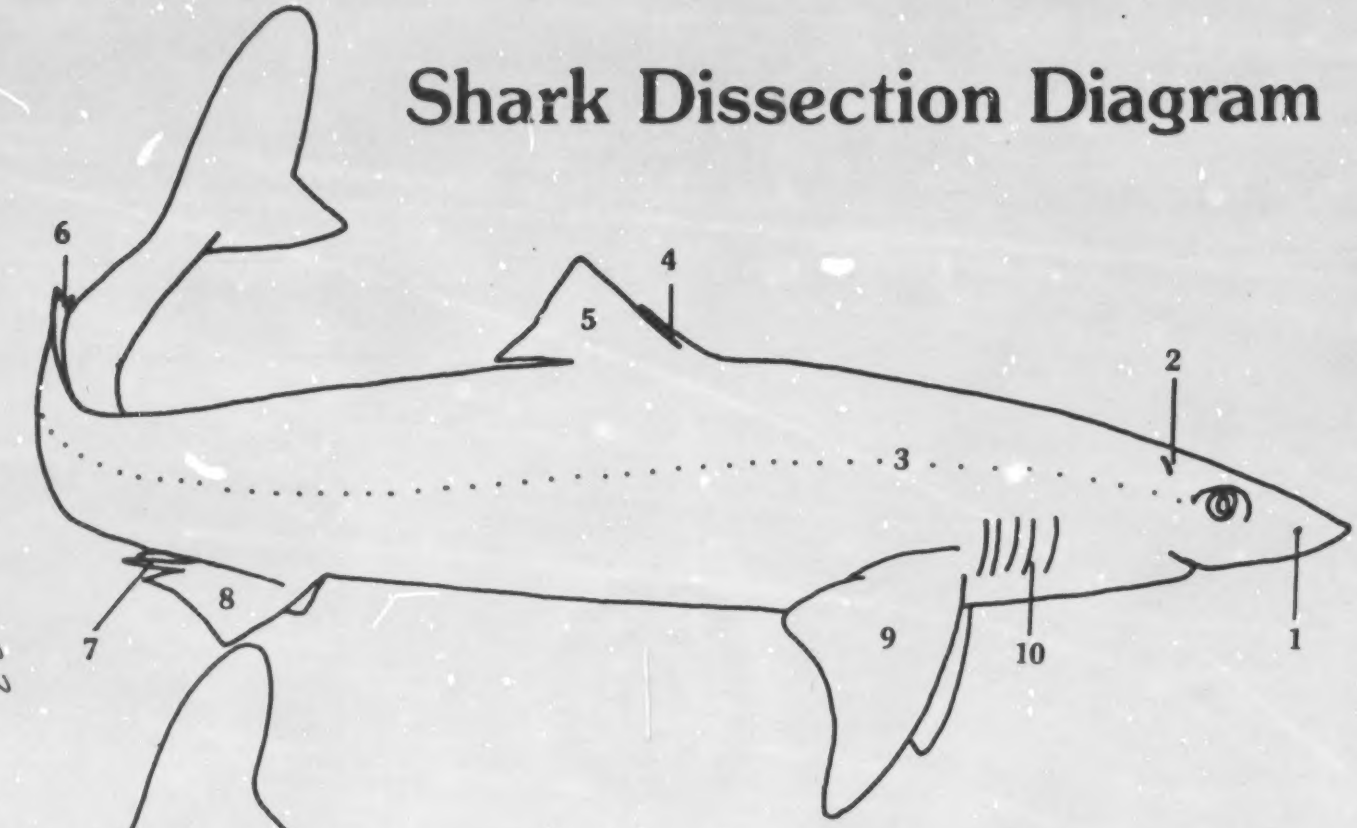
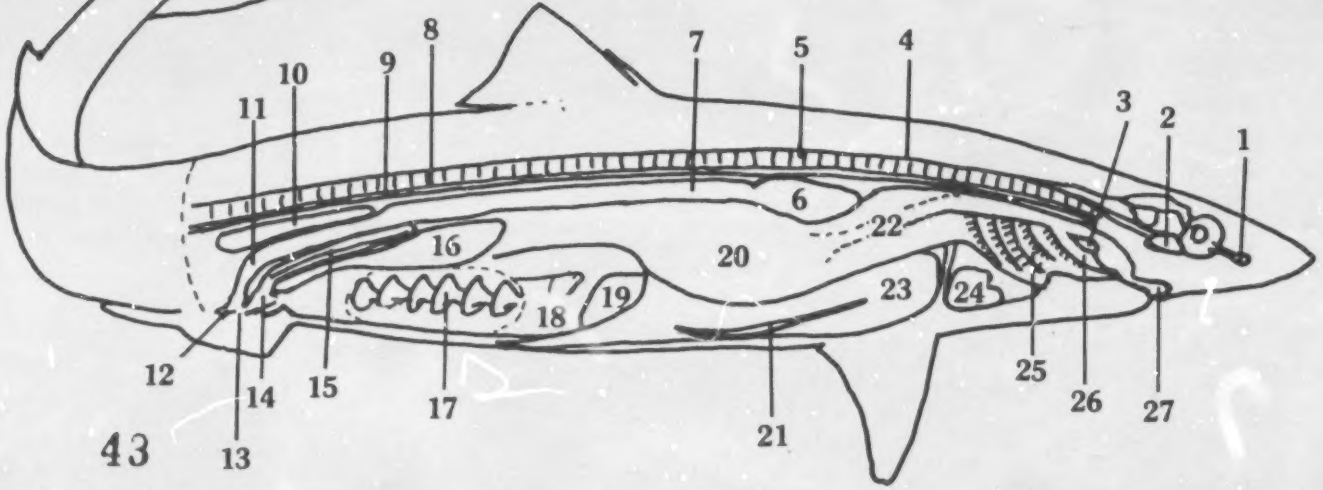
Shark Dissection Diagram





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Exterior (Side View)

1. Nostril
2. Spiracle
3. Lateral line
4. Spine
5. First dorsal fin
6. Second dorsal fin
7. Claspers (male)
8. Pelvic fin
9. Pectoral fin
10. External gill openings

Interior (side view)

1. Olfactory sac
2. Brain
3. Interior spiracle opening
4. Spinal nerve cord
5. Vertebrae
6. Testes (male)
7. *Ductus Differens*
8. Posterior vein
9. Dorsal aorta
10. Kidney
11. Seminal vesicle
12. Genital papilla (male)
13. Anus
14. Cloaca
15. Rectal gland
16. Spleen
17. Spiral valve
18. Intestines
19. Pancreas
20. Stomach
21. Gall bladder
22. Esophagus
23. Liver
24. Heart
25. Gills
26. Pharnyx
27. Mouth

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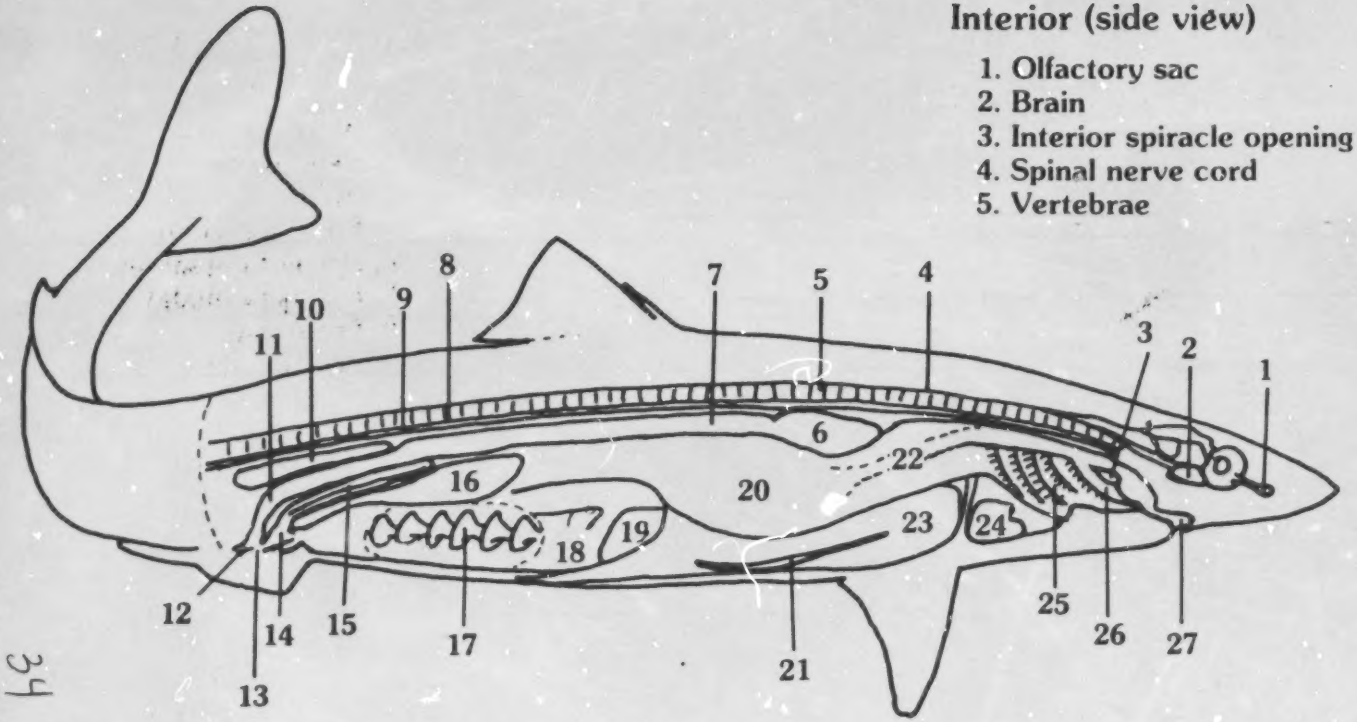

Interior (side view)

1. Olfactory sac
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14. Cloaca
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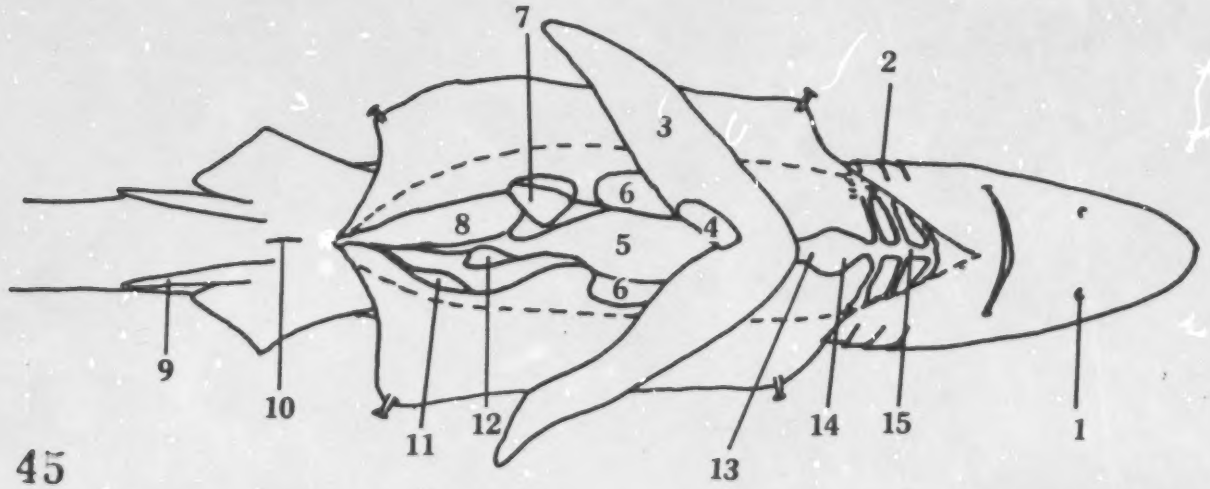
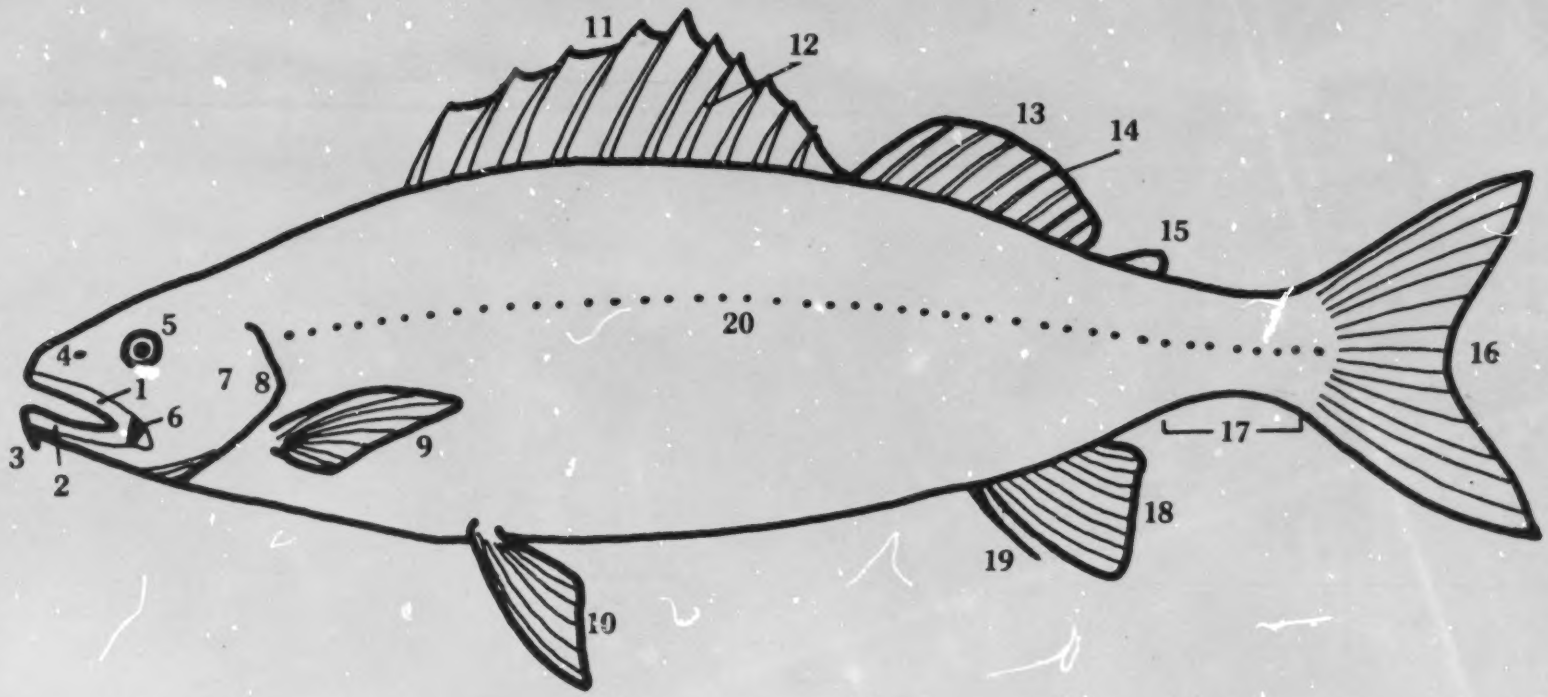
16. Spleen
17. Spiral valve
18. Intestines
19. Pancreas
20. Stomach
21. Gall bladder
22. Esophagus
23. Liver
24. Heart
25. Gills
26. Pharnyx
27. Mouth



Interior (ventral view)

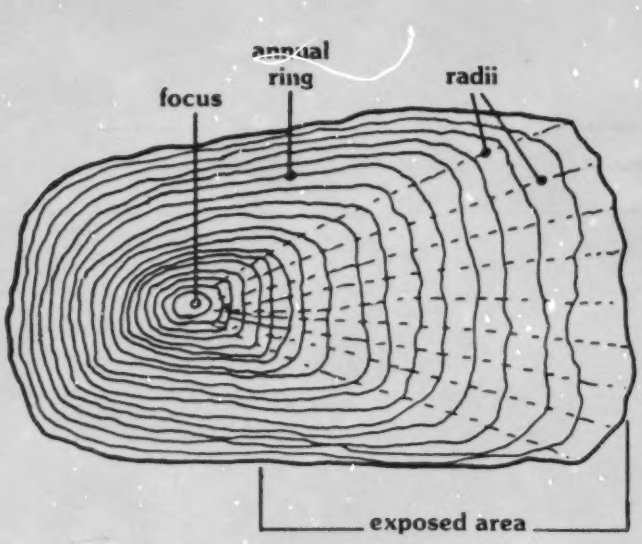
1. Nostril
2. Gill slits
3. Liver
4. Gall bladder
5. Stomach
6. Gonads (ovaries or testes)
7. Pancreas
8. Intestine (spiral valve)
9. Claspers (male)
10. Cloaca
11. Uterus (female)
12. Spleen
13. Ventricle
14. Atrium
15. Aorta

Generalized Bony Fish External Anatomy

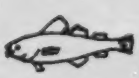


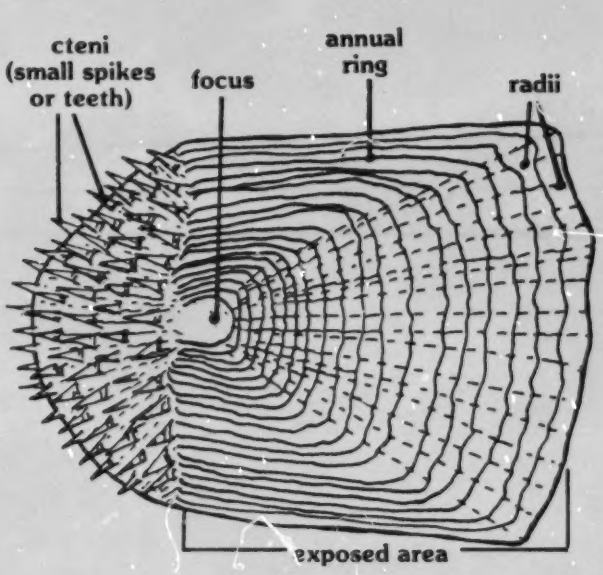
1. Upper jaw
2. Lower jaw
3. Barbel
4. Nostril
5. Eye
6. Maxillary barbel
7. Cheek
8. Operculum
9. Pectoral fin
10. Pelvic fin
11. Spiny (first) dorsal fin
12. Fin spine
13. Soft (second) dorsal fin
14. Fin ray
15. Adipose fin
16. Caudal fin
17. Caudal peduncle
18. Anal fin
19. Anal spine
20. Lateral line

Scale Types and Growth Rings

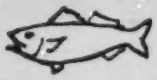


Cycloid Scale
(from cod)

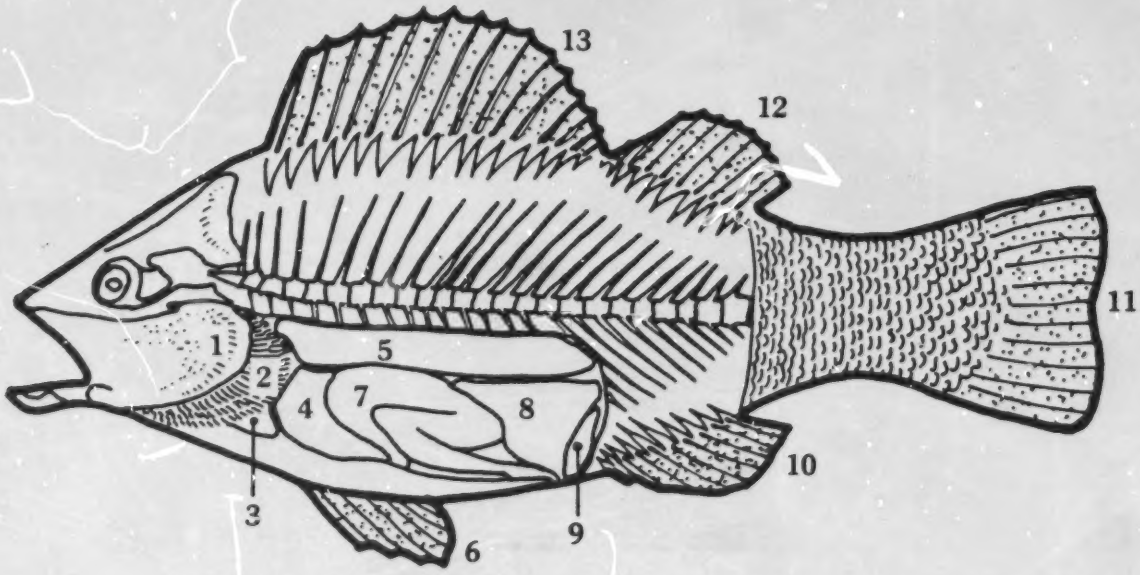




Ctenoid Scale
(from striped bass)



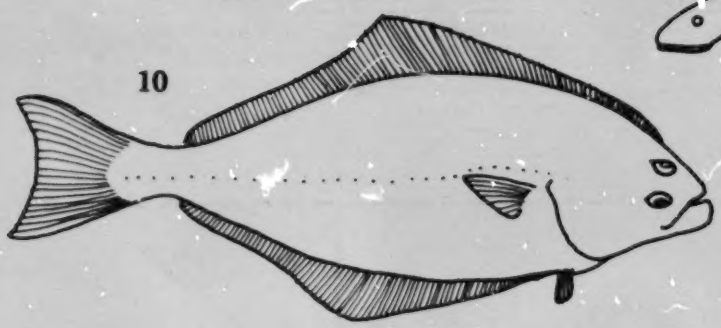
Bony Fish Dissection Diagram



1. Gill rakers
2. Gill filaments
3. Heart
4. Liver
5. Swim bladder
6. Pelvic fin
7. Intestine
8. Gonad
9. Urinary bladder
10. Anal fin
11. Caudal fin
12. Soft (second) dorsal fin
13. Spiny (first) dorsal fin

Key Out These Fish

9



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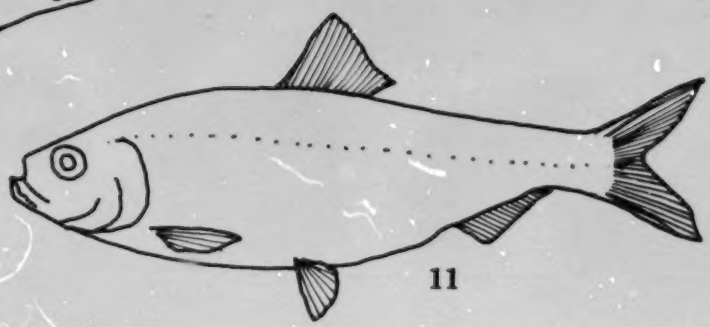

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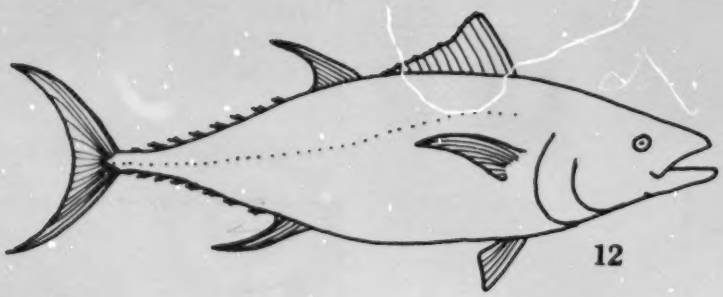

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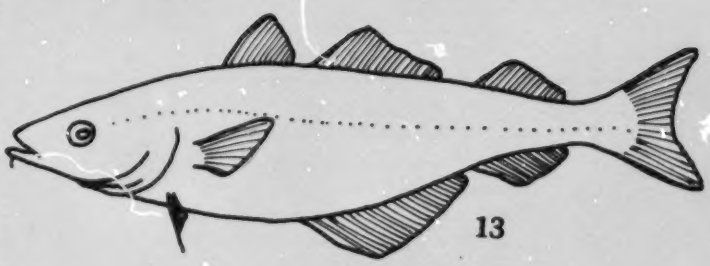

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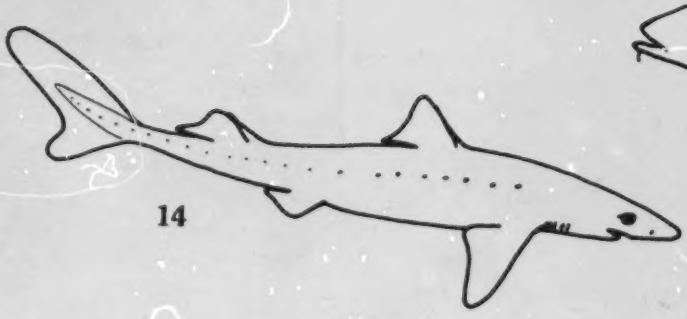

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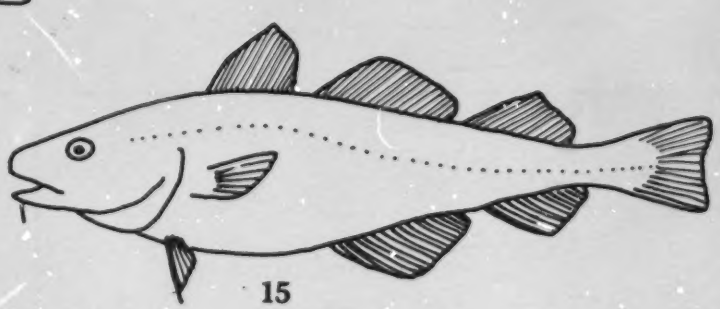

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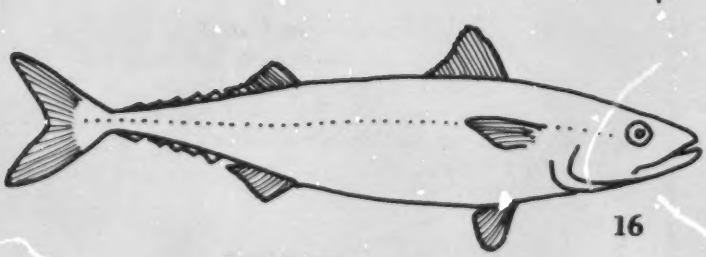

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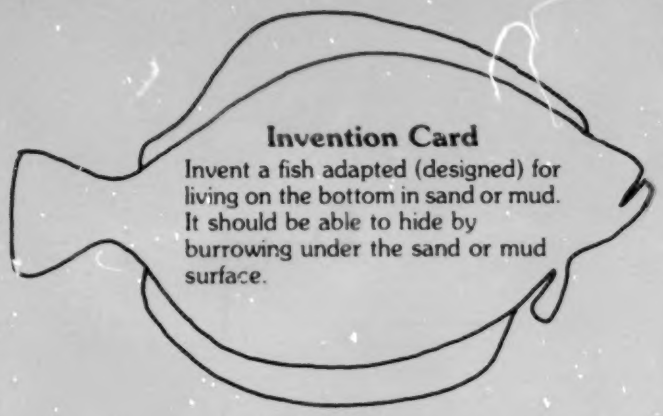
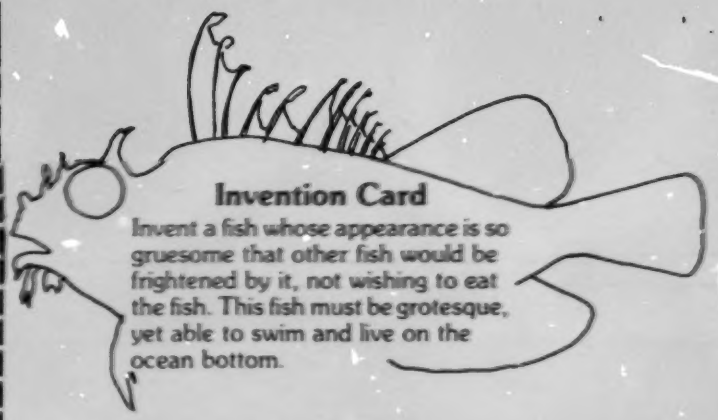


Invention Card

Invent a fish adapted (designed) for living on the bottom in sand or mud. It should be able to hide by burrowing under the sand or mud surface.



Invention Card

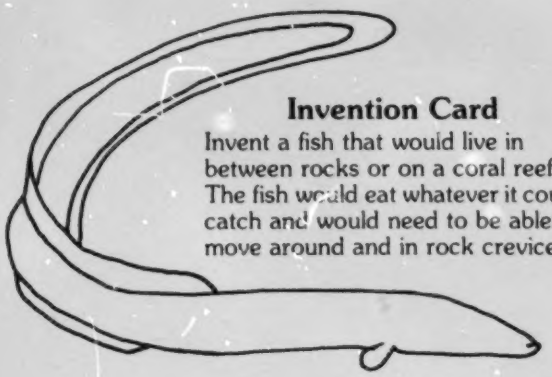
Invent a fish whose appearance is so gruesome that other fish would be frightened by it, not wishing to eat the fish. This fish must be grotesque, yet able to swim and live on the ocean bottom.

Invention Card

Invent a fish that can swim very fast. The fish would live in the water column eating small organisms in the water.

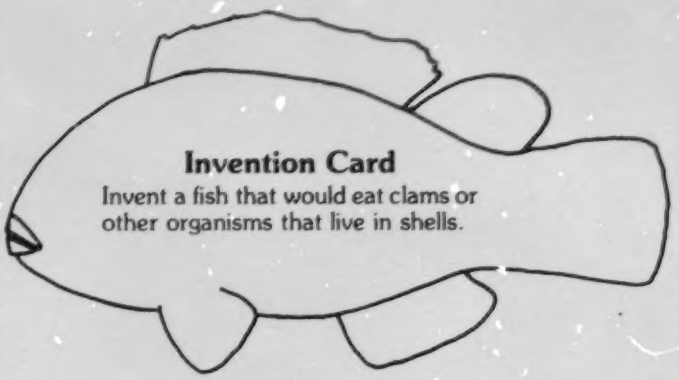
Invention Card

Invent a fish that would escape capture by jumping and gliding over the wave's surface.



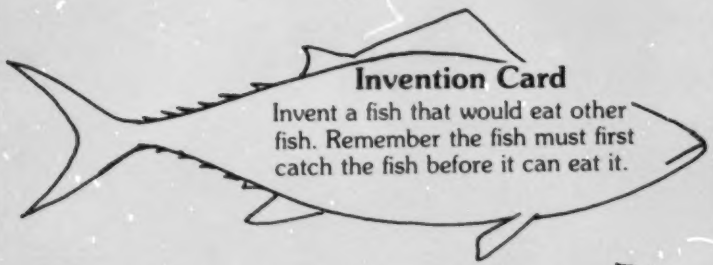
Invention Card

Invent a fish that would live in between rocks or on a coral reef. The fish would eat whatever it could catch and would need to be able to move around and in rock crevices.



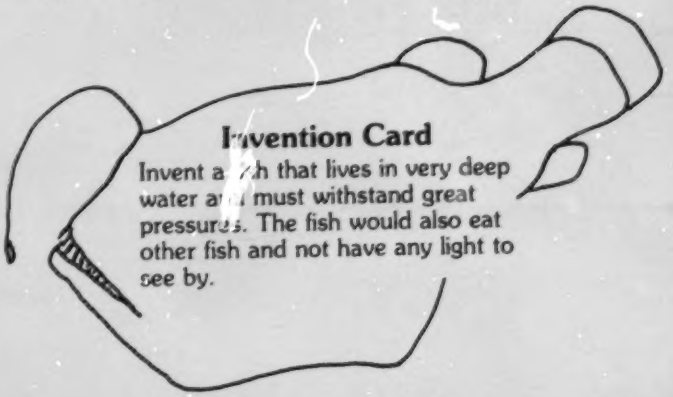
Invention Card

Invent a fish that would eat clams or other organisms that live in shells.



Invention Card

Invent a fish that would eat other fish. Remember the fish must first catch the fish before it can eat it.



Invention Card

Invent a fish that lives in very deep water and must withstand great pressures. The fish would also eat other fish and not have any light to see by.

Fish Key

Sample key for Hammerhead Shark

1. a. Does the fish have a body like a snake? **2** *(no)*
   b. Does the fish not have a body like a snake? **3** *(yes)*

2. a. Does the fish have a beaklike mouth? **American Eel**
   b. Does the fish not have a beaklike mouth? **Lampreys and Hagfish**

3. a. Does the fish have eyes on the same side and a flattened body? **4** *(no)*
   b. Does the fish not have eyes on the same side and no flattened body? **5** *(yes)*

4. a. Does the fish have a forked tail? **Halibut**
   b. Does the fish not have a forked tail? **Flounder**

5. a. Does the fish have placoid scales? **6** *(yes)*
   b. Does the fish have scales other than placoid? **7** *(no)*

6. a. Does the fish have a pointed head? **Dogfish shark** *(no)*
   b. Does the fish not have a pointed head? **Hammerhead Shark** *(yes)*

7. a. Is the fish body full moon shaped with a little caudal fin? **Ocean sunfish**
   b. Is the fish body not distinctly moon shaped and has a highly visible larger caudal fin? **8**

8. a. Is the fish club shaped like a baseball bat? **Wolffish**
   b. Is the fish body not club shaped like a baseball bat? **9**

9. a. Is there evidence of a chin barbel? **10**
   b. Does the fish have no chin barbels? **13**

10. a. Is the caudal fin not notched or only slightly (just barely) notched? **11**
    b. Is the tail decidedly notched? **12**

11. a. Does the fish have three distinct dorsal fins (top side)? **Cod**
    b. Does the fish have two distinct dorsal fins? **Hake**

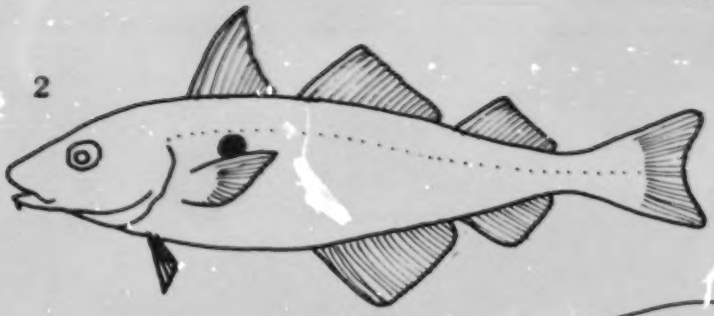
12. a. Does the lower jaw extend beyond the upper jaw? **American pollock**
    b. Does the lower jaw not extend beyond the upper jaw? **Haddock**

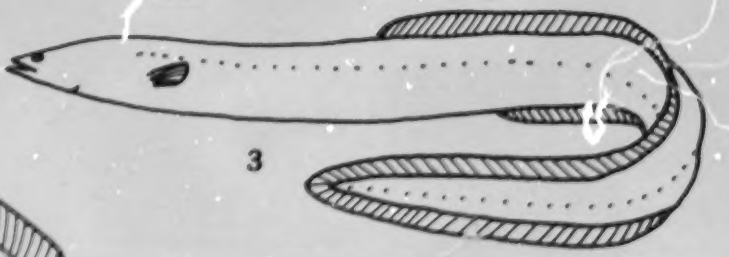
13. a. Does the fish have finlets (small fin like growth between tail and dorsal and anal fin)? **14**
    b. Does the fish not have finlets? **15**

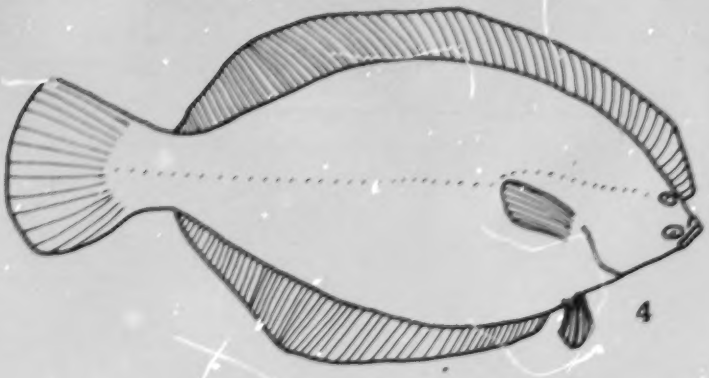
14. a. Are the dorsal fins distinctly separated? **Mackerel**
    b. Are the dorsal fins not separated distinctly? **Tuna**

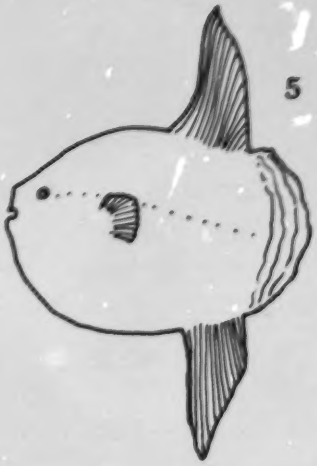
15. a. Does the fish have a small adipose fin (small fleshy fin between the caudal and dorsal fin)? **Smelt**
    b. Does the fish not have a small adipose fin? **Alewife**

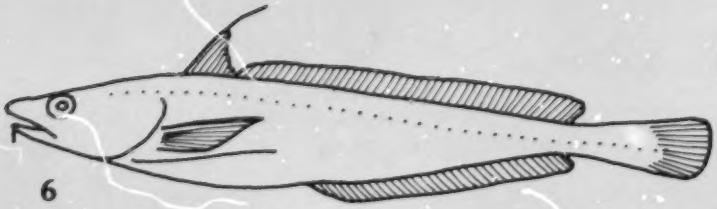
Key Out These Fish

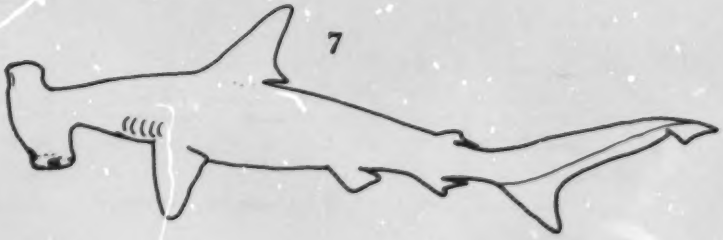


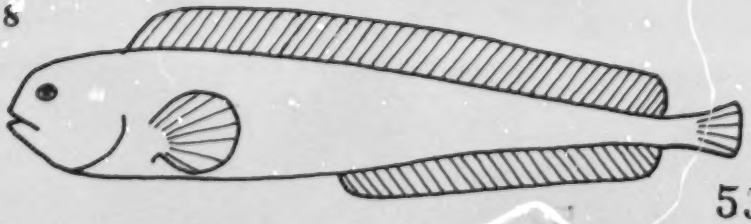












Fisherman's Luck

No cod today, subtract all cod so far

Fisherman's Luck

No dogfish today, subtract all dogfish so far

Fisherman's Luck

No hake today, subtract all hake so far

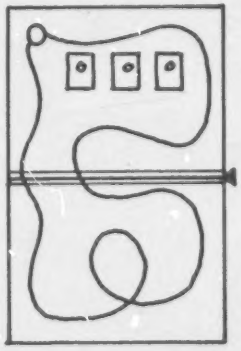
note to teachers:
Duplicate each set of cards (Fisherman's Luck, Radio Check, Catch Cards) on different colored paper, if possible.

Fisherman's Luck

Good luck! Double your next fish catch

Trawlerman Game Board

Copy both sides and assemble as shown below



Tape together here

Fisherman's Luck

No haddock today, subtract all haddock so far

Catch Tally Sheet

Species	Kilogram value in cents. This will vary and you may adjust the prices if you wish.	
Cod	$.40 kg.	
Haddock	$.80 kg.	
Hake	$.30 kg.	
Halibut	$3.00 kg.	
Flounder	$.60 kg.	
Dogfish shark throw the die if ≥4 no market today so no money.	$.20 kg.	
Tuna	$3.50 kg.	

Contact DMR for update on price.

Fisherman's Luck

No flounder today, subtract all flounder today

Fisherman's Luck

Engine running poorly (leaking oil) go back to mooring

Fisherman's Luck

A baby is due at home, go to mooring
Good luck! Double you next

Fisherman's Luck

It is really hot and you didn't ice fish, lose 1/2 catch

Fisherman's Luck

Go back to mooring (port) to refuel

Fisherman's Luck

The Coast Guard is checking for smuggling, lose 2 turns

Fisherman's Luck

Your trawl has been damaged by dogfish, lose 2 turns

Fisherman's Luck

Your crew is really ready! Take a free turn

Fisherman's Luck

Engine is running rough, lose 2 turns

Fisherman's Luck

Your trawl has been badly damaged, go to mooring

Fisherman's Luck

You forgot to ice the fish! Lose 1/4 catch

Fisherman's Luck

Go to next radio check

Fisherman's Luck

You're doing well today, go to space before next figure and roll the dice

Fisherman's Luck

Fish have been sliding in the hold due to poor storage, lose 1/2 catch

Fisherman's Luck

You are leaking due to a log you hit, lose 1 turn

Fisherman's Luck

Man overboard, lose 2 turns

Radio check

Squall hits
Lose 1 turn

Radio check

Weather clear
Seas rough
You can't keep any

Radio check

Boy, are you in for trouble!
Hurricane warnings, go back
to port

Radio check

Weather clear
Seas choppy
Next fish catch, keep 1/2
(Skip next fish catch)

43

Radio check

Weather, intense rain
Seas rough
Unable to fish

Radio check

Weather clear
Calm seas
No problem

Radio check

Weather rainy
Calm seas
Only problem is you get wet

Radio check

Weather rainy
Seas choppy
Keep only 1/2 next fish catch
(skip next catch)

Catch Tally Sheet

Species	Kilogram value in cents. This will vary and you may adjust the prices if you wish.	
Cod	$.40 kg.	
Haddock	$.80 kg.	
Hake	$.30 kg.	
Halibut	$3.00 kg.	
Flounder	$.60 kg.	
Dogfish shark throw the die if ≥4 no market today so no money.	$.20 kg.	
Tuna	$3.50 kg.	

Contact DMR for update on price.

Catch Card

You have caught 300 kilograms dogfish shark

Catch Card

You have caught 500 kilograms cod

Catch Card

You have caught 200 kilograms cod

Catch Card

You have caught 500 kilograms cod

Catch Card

You have caught 200 kilograms dogfish shark

Catch Card

You have caught 300 kilograms cod

Catch Card

You have caught 100 kilograms cod

Catch Card

You have caught 500 kilograms cod

Catch Card

You have caught 500 kilograms dogfish shark

Catch Card

You have caught 200 kilograms halibut

Catch Card

You have caught 50 kilograms cod

Catch Card

You have caught 100 kilograms hake

Catch Card

You have caught 200 kilograms halibut

Catch Card

You have caught 50 kilograms flounder

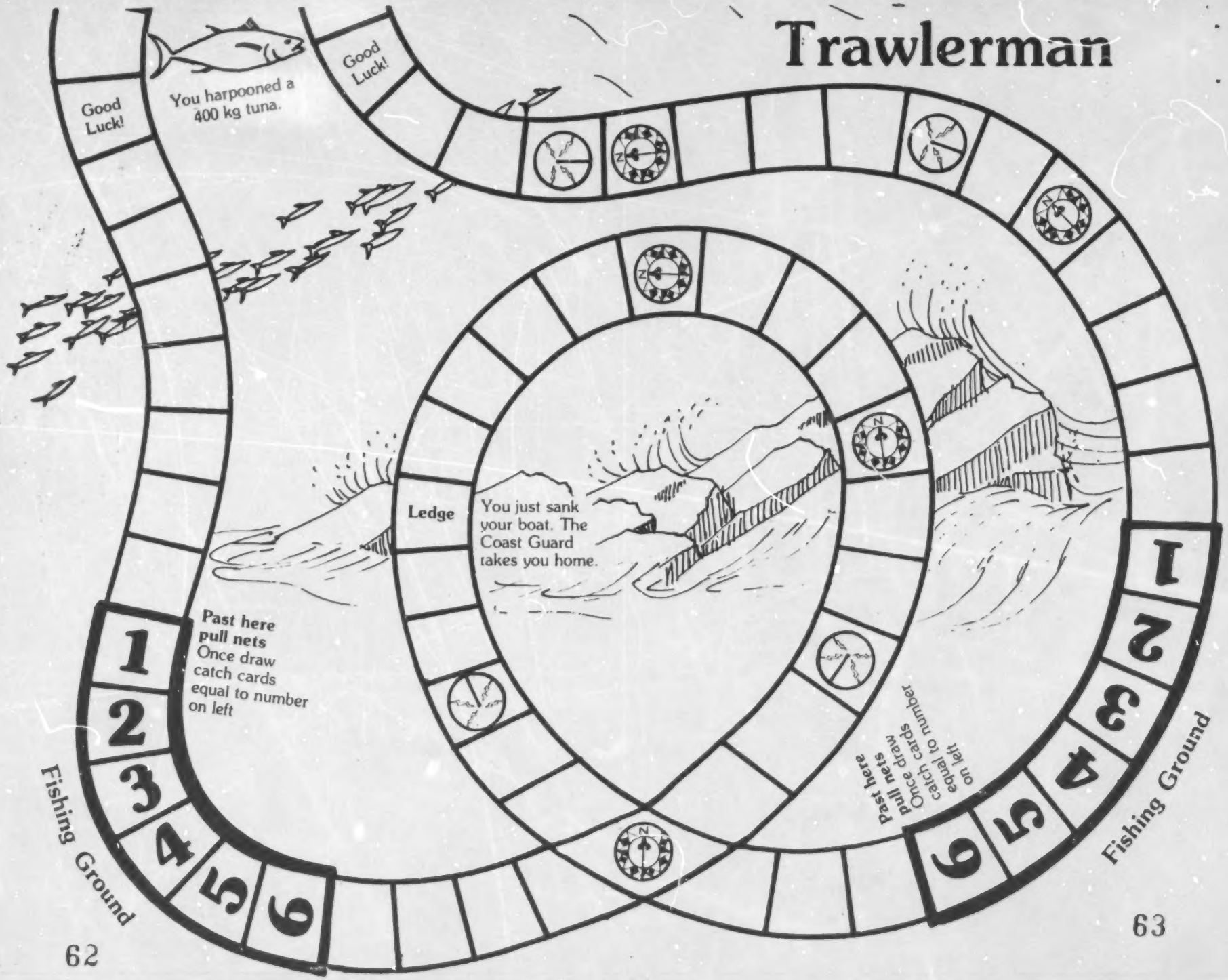
Catch Card

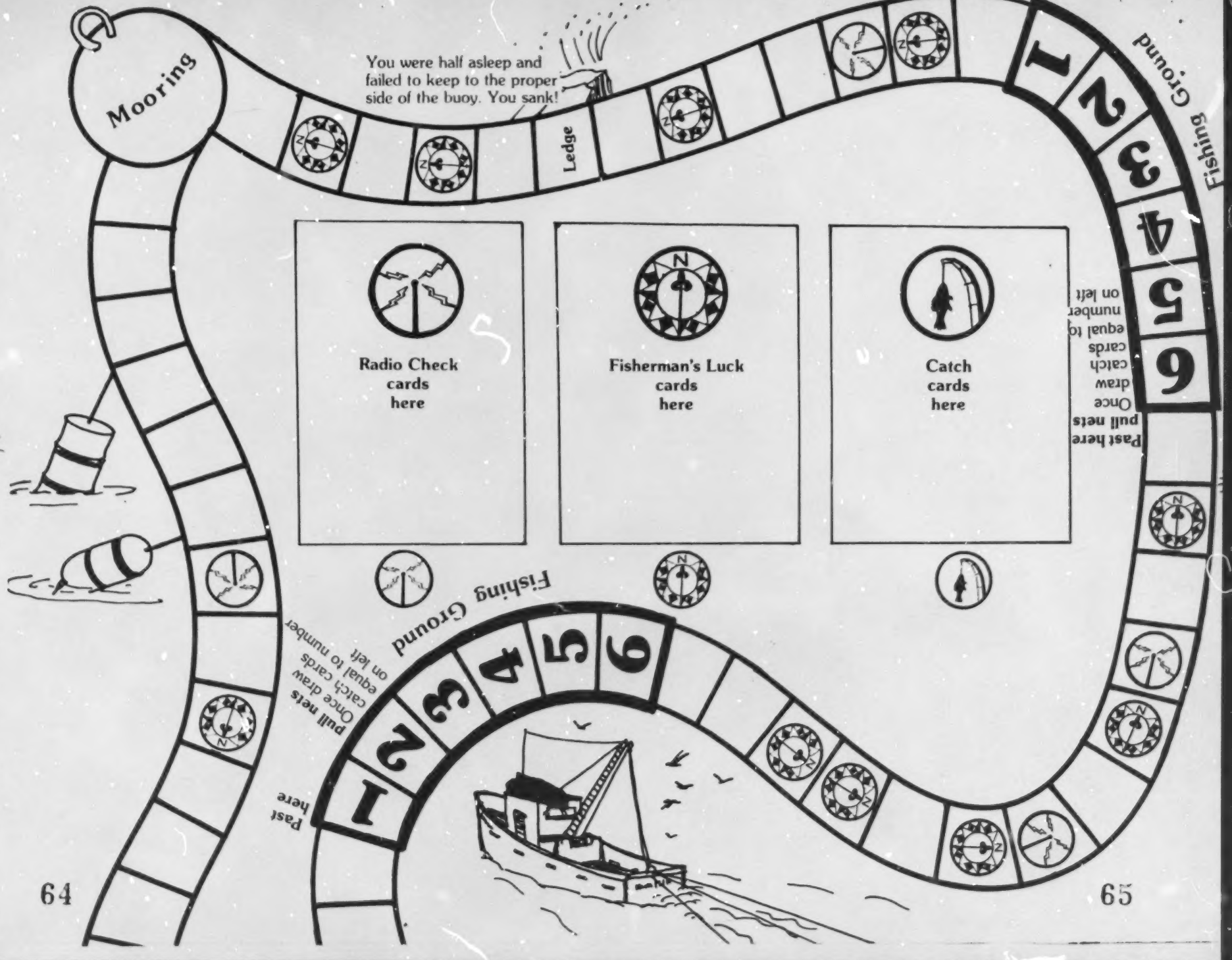
You have caught 100 kilograms haddock

Catch Card

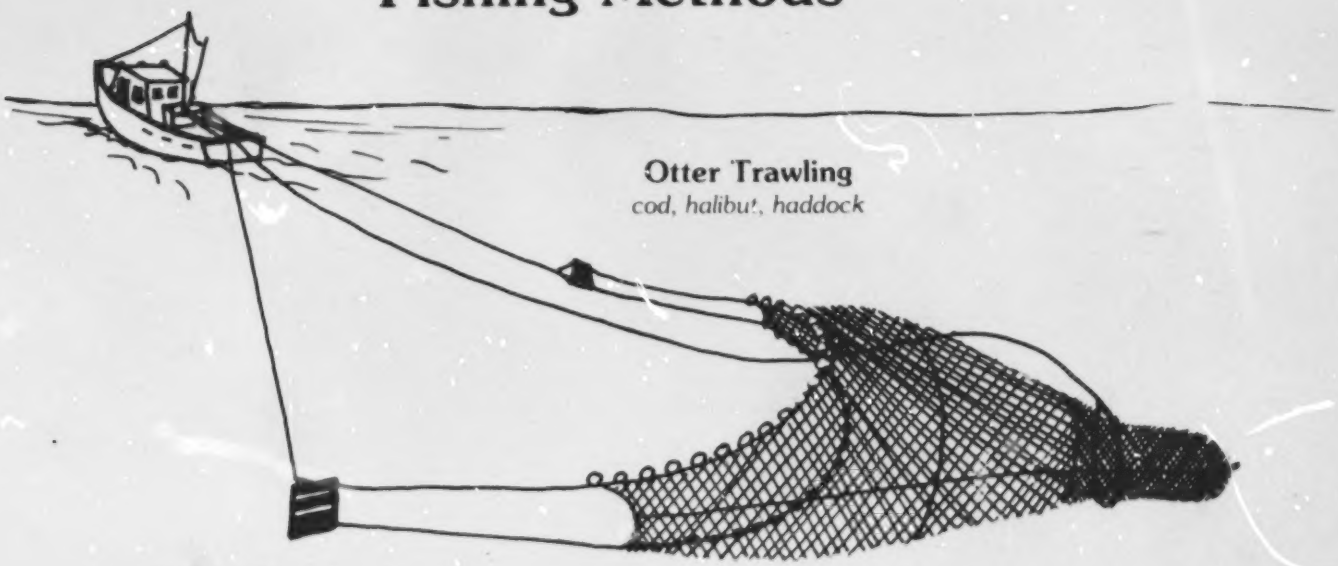
You have caught 100 kilograms halibut

Trawlerman

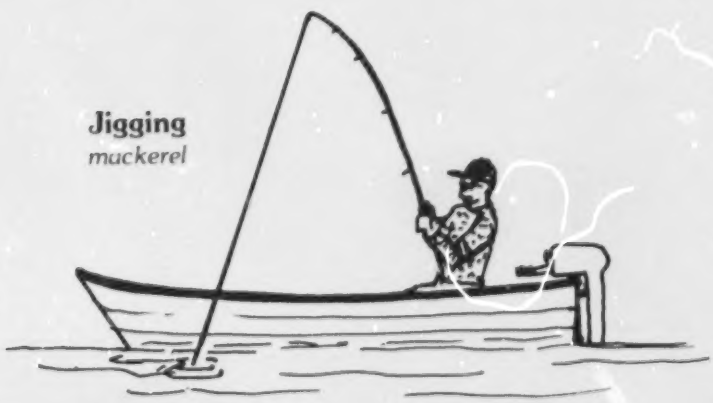

Good Luck!
You harpooned a 400 kg tuna.
Good Luck!
Ledge
You just sank your boat. The Coast Guard takes you home.
Past here pull nets Once draw catch cards equal to number on left
Fishing Ground
Past here pull nets Once draw catch cards equal to number on left
Fishing Ground


Mooring
You were half asleep and failed to keep to the proper side of the buoy. You sank!
Ledge
Fishing Ground
1
2
3
4
5
6
Radio Check cards here
Fisherman's Luck cards here
Catch cards here
Past here pull nets Once draw catch cards equal to number on left
Fishing Ground
Past here pull nets Once draw catch cards equal to number on left

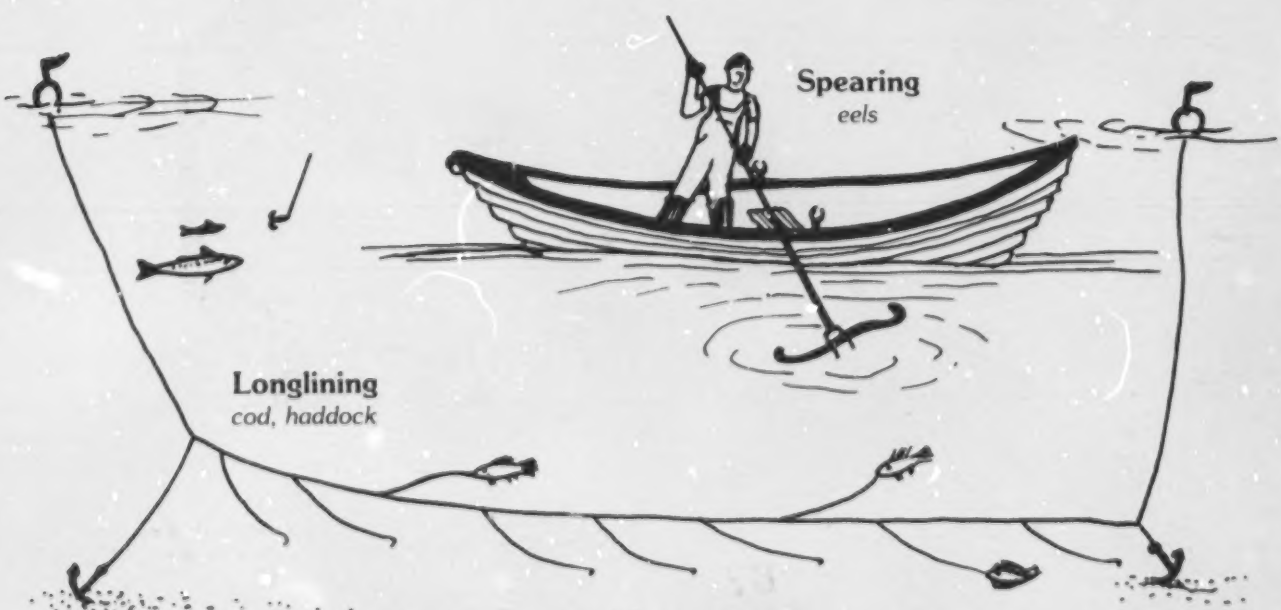
Fishing Methods



Otter Trawling
cod, halibut, haddock



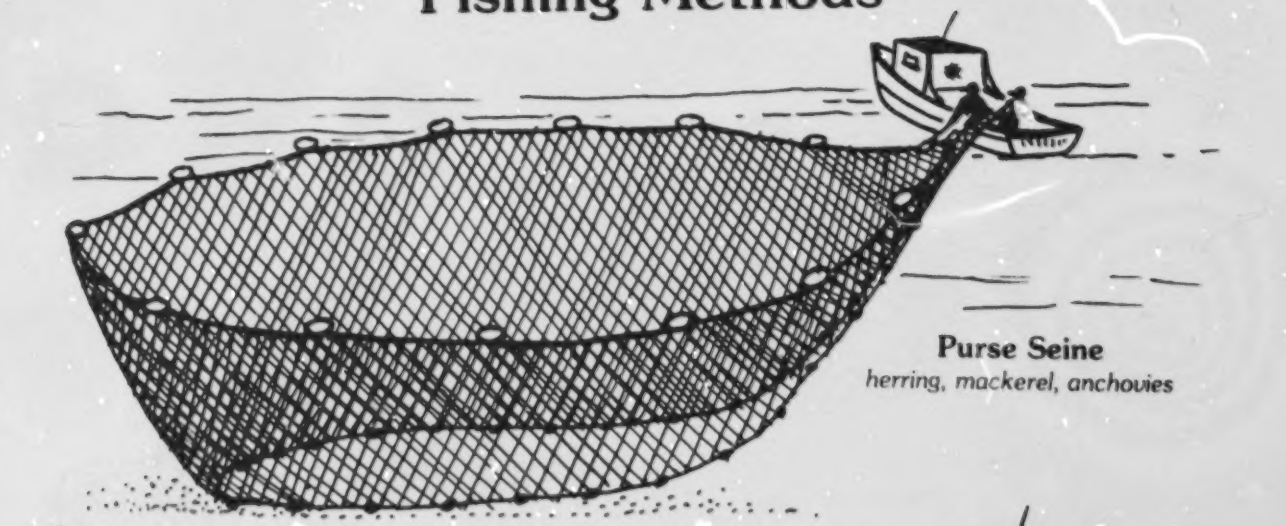
Jigging
mackerel



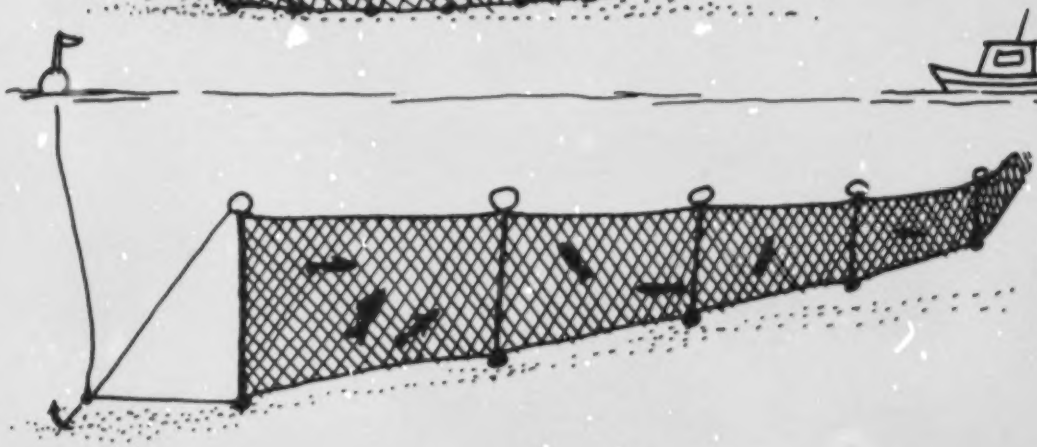
Spearing
eels

Longlining
cod, haddock

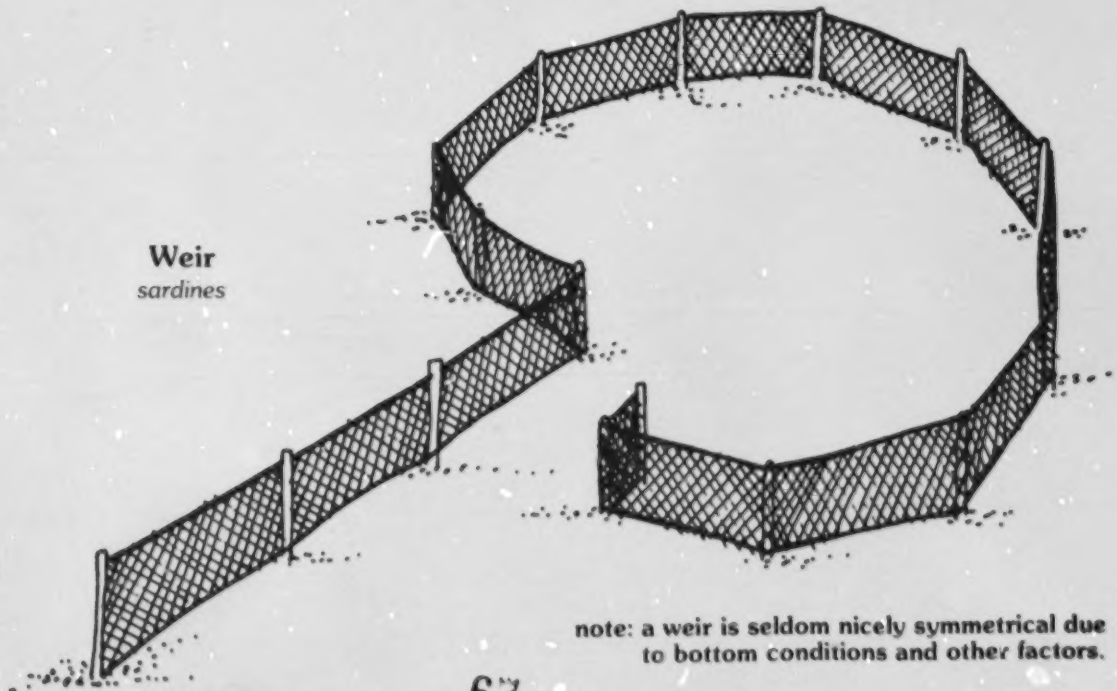
Fishing Methods



Purse Seine
herring, mackerel, anchovies



Gill Net
herring, cod
sharks, pollock



Weir
sardines

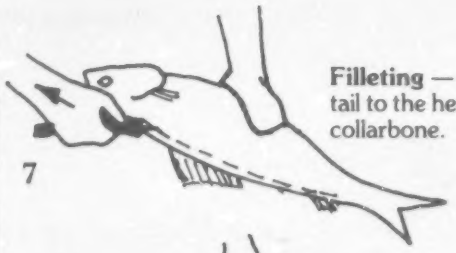
note: a weir is seldom nicely symmetrical due to bottom conditions and other factors.

6

Steaking a dressed fish

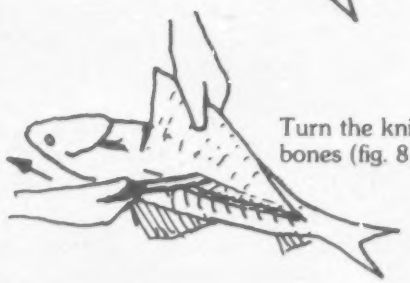
Cutting Steaks — Large size dressed fish may be cut crosswise into steaks, about an inch thick (fig. 6).

Filleting a whole fish



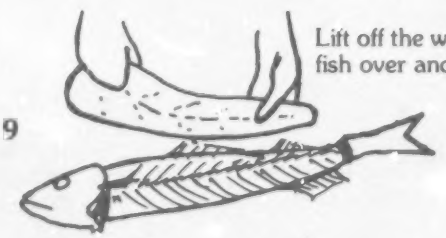
7

Filleting — With a sharp knife cut along the back of the fish from the tail to the head (fig. 7). Then cut down to the backbone just back of the collarbone.



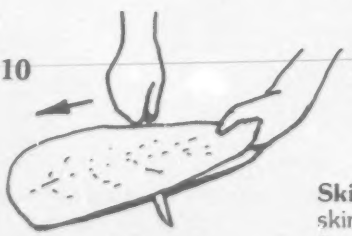
8

Turn the knife flat and cut the flesh away from the backbone and rib bones (fig. 8).



9

Lift off the whole side of the fish or fillet in one piece (fig. 9). Turn the fish over and cut the fillet from the other side.



10

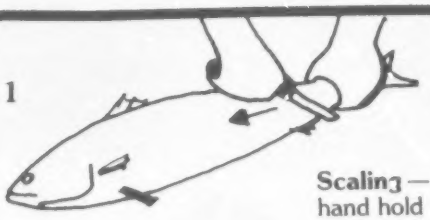
Skinning a Fillet — If you wish, you may skin the fillet. Place the fillet skin side down, on a cutting board. Hold the tail end tightly with your fingers and with a sharp knife cut down through the flesh to the skin about ½ inch from the end of the fillet. Flatten the knife against the skin by slicing the knife forward while holding the tail end of the skin firmly between your fingers (fig. 10).

Cleaning and Dressing Fish

Materials:

Scaling knife (optional), filleting knife, cutting board or surface, sink for cleaning, garbage bags for "remains," towels and of course, safety.

1



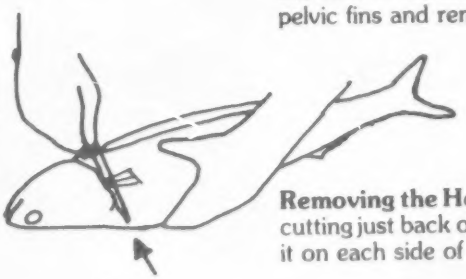
Dressing a whole fish for baking

Scaling — Wash the fish. Place the fish on a cutting board and with one hand hold the fish firmly by the head. Holding a knife almost vertical, scrape off the scales, starting at the tail and moving toward the head (fig. 1).

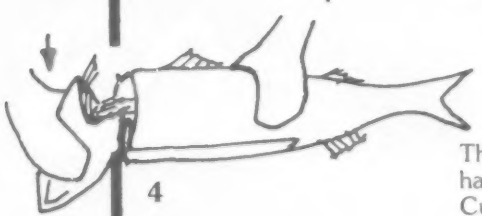
2

Cleaning — With a sharp knife cut the entire length of the belly from the vent to the head. Remove the intestines. Next, cut around the pelvic fins and remove them (fig. 2).

3

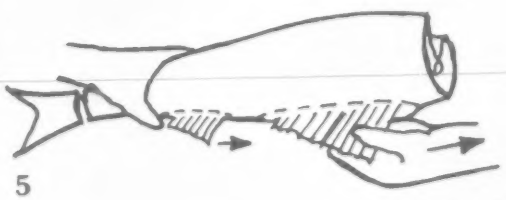


Removing the Head and Tail — Remove the head and pectoral fin by cutting just back of the collarbone. If the backbone is large, cut down to it on each side of the fish (fig. 3).



4

Then place the fish on the edge of the cutting board so that the head hangs over and snap the backbone by bending the head down (fig. 4). Cut and discard any remaining flesh that holds the head to the body. Cut off the tail.



5

Removing the Fins — Next remove the dorsal fin, the large fin at the back of the fish, by cutting along each side of the fin (fig. 5). Then give a quick pull forward toward the head and remove the fin with the back bones attached (fig. 5). Remove the ventral fin in the same way. Never trim the fins off with shears or a knife because the root bones at the base of the fins will be left in the fish. Wash the fish thoroughly in cold running water. The fish is now dressed or pan-dressed depending on its size.

These forms are passed out in classes at the very beginning to tell a little about the eating habits of students.

What Finfish Do You Eat?

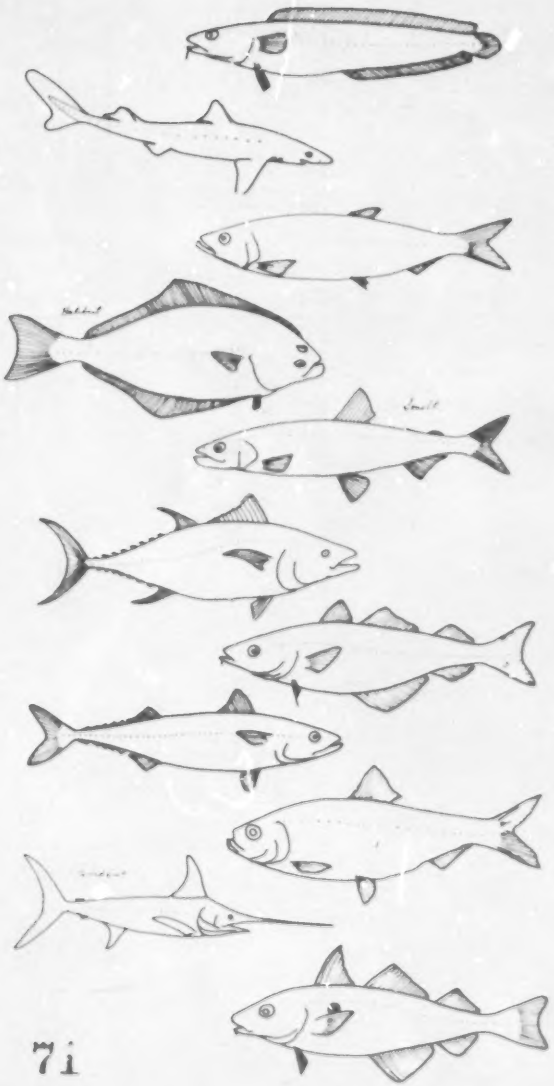
Finfish	*Often*	*Sometimes*	*Seldom*	*Never*	*Tasted But Did Not Like*
Smelt					
Shark					
Salmon					
Perch					
Mackerel					
Swordfish					
Halibut					
Haddock					
Tuna					
Cod					
Sole					
Flounder					
Cusk					
Pollock					
Whiting					
Sardines					

Fish Purchasing

Table of Fish Products and Cents or Dollars

	Price/Wt.	Form: Fillets, Steaks, Breaded, Etc.
Canned Fish		
Fresh Fish		
Frozen Fish		
Hamburger		

Common Gulf of Maine Fish Checklist



Fish Common Name	Scientific Name	Water Column Location	Market Size Kg.	Commercial Usage	Common Fishing Method
Cusk	*Brosme brosme*	bottom (groundfish)	+4.5 kg.	fresh	long lines
Spiny Dogfish	*Squalus acanthias*	surface to bottom	+4 kg.	breaded	otter trawl
Herring (sardine)	*Clupea harengus*	pelagic surface to bottom	+.6 kg.	canned fillets schmaltz (breaded, pickled)	weirs
Atlantic Halibut	*Hippoglossus hippoglossus*	bottom (groundfish)	+20 kg. to 90 kg.	steaks	otter trawl
Smelt	*Osmerus mordax*	pelagic	+.15 kg.	frozen fresh	dip nets
Tuna	*Thunnus thynnus*	pelagic	+450. kg.	gutted & headed steaks, fillets fresh or frozen	harpoon
American Pollock	Pollachius *virens*	pelagic	+6.0 kg.	smoked, fresh, salted, frozen fillets	gill nets otter trawl
Mackeral	*Scomber scombrus*	pelagic	+.6 kg.	canned whole fresh	purse seine
Alewife	*Pomulobus pseudoharengus*	pelagic	+.20 kg.	fillets fresh, whole smoked	weirs
Swordfish	*Xiphias gladius*	pelagic	+70. kg.	steaks	harpooned
Haddock	*Melanogrammus aeglefinus*	bottom (groundfish)	+1.5 kg.	fresh fillets fresh, frozen	otter trawl

Northern New England Marine Education Project

The objective of NNEMEP is to encourage and support marine education among the teachers of Northern New England so that their students will appreciate the importance of water in their lives and in the life of the planet. The project has received support from the College of Education of the University of Maine at Orono, the National Science Foundation, and the Maine-New Hampshire Sea Grant Program.

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